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ELECTRIC RAILWAY ACTIVITY.

The activity in electric railway construction seems to be greater than in any other electrical industry. In some sections the lines already constructed and those planned form networks almost as imposing as a railway map. Indeed, the remarkable expansion of the trolley lines of several of the middle-western states raises the question whether the work is not being overdone.

Electrification of steam railways, as it is called, is also attracting attention. This is particularly the case in England, where, due to peculiar conditions of short hauls and heavy local traffic, often the best opportunities for this application are afforded. Some of the large roads there are introducing electricity on certain sections. The electrical equipment of the Liverpool-Mersey road, running through a tunnel under the Mersey River, has been put into service. This road claims the honor of being the first English railroad to be operated electrically.

THE SOURCE OF THE ENERGY EMITTED BY RADIUM.

The scientific world is at present interested in accounting for the comparatively large amount of energy emitted by radium, although this material undergoes no apparent change. Various suggestions have been made, one of these being that radium, by some peculiar property, is able to abstract energy from rapidly moving molecules of air which impinge upon it, but does not give up energy to slow-moving particles when these strike it. In other words, the action of the material was likened to that of Maxwell's imaginary demons. Another theory suggested was that radium is in an unstable condition and the energy emitted is due to molecular changes.

A Suggestion by Dr. J. J. Thomson.

In a recent article Dr. J. J. Thomson points out that none of the theories put forward to account for this emmission of energy will bear investigation, except that based upon atomic transformation. He shows that the energy can not be abstracted from the air, because when radium is enclosed in a block of ice it continues to melt the ice, although no heat energy can be transmitted through the ice to the radium.

The Intrinsic Energy of Radium.

Dr. Thomson then makes a calculation of the intrinsic energy contained in an atom of radium. If each atom was formed of a positive and a negative electron and separated by distance of only 10^{-8} centimetre the intrinsic energy possessed by the atom would be so great that one per cent of this would be able to maintain the radiation of radium, as measured by Currie, for thirty thousand years. This offered explanation seems more sensible than those which assume the presence of some cosmic radiation. However, a suggestion of the reason why this action takes place is now wanted. Dr. Thomson's calculation of the energy of matter is certainly awe-inspiring. Here is a substance which is able to melt half its own weight of water once an hour for thirty thousand years and at the end of that time have ninety-nine per cent of the energy with which it started.

WAVE POWER.

Although it has been shown again and again that it is impracticable to make use of the power of waves even under the best conditions, from time to time schemes for doing this crop up. No objection can be raised if an inventor spends his time in attempting to solve the wave motor problem, but it is very desirable that those who are asked to invest money in such schemes should know what has been done and the conclusions that have been reached by well-known engineers after careful examination of the project.

A New Scheme.

The latest scheme which has come to our notice is that of a Pennsylvania inventor. His plan is announced very indefinitely in the daily press. "The invention is to run five hundred feet into the water, shore connections being made by a system of cogs and shafting. One man can operate the entire apparatus from the generator to the dynamos. The power to be obtained is governed only by the size of the apparatus."

Wave Motors Possible.

There is very little difficulty in constructing a motor which will be operated by waves and will deliver power—indeed, this has been done on the Pacific coast, but to construct an apparatus which will develop power in any quantity, necessitates a large investment which could be employed more profitably in other ways, and besides there is a factor of uncertainty involved which would be fatal for all but minor applications.

AUTOMOBILE REGULATIONS.

There is some satisfaction in the way recent automobile contests have been conducted in this country. The automobile is yet in an early stage of development, and contests intended to bring out defects and merits are of much value to the owner and manufacturer. Thus the contest held in New York last week was useful and sensible. Abroad they have gone into high speed races, almost invariably with disastrous results. Accidents of this kind injure automobiling in all countries, and beyond establishing a new record have no value. High speed is only a question of large power and a running gear strong enough to stand it, the rest depends upon the nerve of the operator. Every engineer knows that speeds of sixty or even eighty miles an hour are perfectly possible on a good road, but is there any one who desires to run at this terrific pace even supposing it were permitted by the authorities. The same amount of time and ingenuity spent in perfecting machines for every-day use would be far more beneficial to all interested in the automobile.

The New York Regulations.

Automobilists in New York state are rather disgruntled at this time on account of the new state laws which seem to be too stringent. Automobiles are in a minority at present and the best way to have this unjust law repealed is not to bring the automobile into discredit by repeatedly violating the statute. When the public learns that the automobile is something more than a toy for the few, a sensible law will be demanded and passed. A law restricting the maximum speed of street railways to eight miles an hour could hardly be enforced for a single day.

Rights of Horse Drivers.

Another phase of the subject calls for a sensible understanding between automobile and horse owners. The new law allows the driver of a horse to stop an automobile by holding up his hand, and if every driver should exercise his right progress of automobiles would be slow, if not impossible. The president of the Road Drivers' Association, of New York, suggested that a mass meeting be held at which some understanding can be reached so that certain drives may be considered as reserved for horses and others for automobiles. This would seem to be difficult, if not impracticable, but we would urge upon automobilists the desirability of recognizing the rights of others. The automobile has a great future before it, but the horse as a means of transit has still a long lease of life, and it is probable that for some time to come road regulations will be dictated more with reference to the demands of the animal than the machine. No good can come from disregarding present conditions and much harm may result.

INDUCTION MOTORS FOR FACTORY OPERATION.

While the induction motor is not used as extensively for driving machine tools or other factory work as is the shunt motor, this motor possesses certain characteristics which it is well to look into when the problem of factory operation is under consideration. The induction motor is exceptionally simple in construction, probably standing in this respect next to the static transformer. It has, it is true, a revolving part, but as there is no need of slip rings or a commutator, the only parts requiring attention are the bearings. In motors of modern design, the bearings need not be inspected frequently, and seldom give trouble.

The Induction Motor a Constant-Speed Machine.

In operation the induction motor has the same general characteristics as the continuous-current shunt motor. It is essentially a constant-speed machine, but like the shunt motor, the speed falls off slightly as the load increases. The decrease in speed can be made as small as desired, as this is simply a question of design. The speed of the motor is less affected by changes in voltage than is the shunt motor, but the maximum output of the induction motor varies nearly proportionally to the square of the voltage, and for this reason it is necessary that the potentials of circuits supplying motors running near their full loads should be kept up to normal.

Starting Induction Motors.

In starting induction motors the same general precautions should be taken as is necessary with shunt motors, except that for small machines no starting resistance is needed. The properties of the alternating circuit prevent a dead short-circuit when the starting switch is closed. With motors of larger power this method of starting is not permissible, because of the heavy starting current not only throwing too severe a load upon the circuit, but causing an undesirable lowering of the voltage. It is not difficult to prevent this, and but two simple methods need be mentioned. A low voltage may be applied to the motor by means of a transformer, and after the machine has reached its normal speed, the full voltage of the circuit is then thrown on. This does away with the objectionable drain on the supplying circuit, but it does not add to the starting effort of the motor, which is, unfortunately, not good. The other way is analogous to the usuual method of starting shunt motors—that is, by introducing a starting resistance into what, for the sake of comparison, we may call the armature of the motor. This resistance not only prevents an excessive starting current, but greatly improves the starting effort of the motor, so that it is possible by proper design to obtain the maximum turning effort at the moment of starting. This resistance is cut out gradually as the motor speeds up, and is short-circuited when normal speed has been reached. The method is, of course, inefficient, but for starting purposes this is a small matter.

Speed Variation.

As the induction motor is normally a constant-speed machine, it is more suitable for that class of work where speed variation is not necessary, or where other means seem desirable to effect the change. The speed of the motor, however, can be varied in several ways. The ideal way would be to change the frequency of the alternating-current supply, for since the motor tends to run at synchronous speed, its speed will change with the frequency. This method is impracticable in general, though a system similar to the direct-current multiple-voltage system might be used. The speed of the motor can also be changed by changing the number of poles set up by the primary winding. This calls for a special winding, and gives but three or four changes. The method has been used both in this country and abroad to some extent. A third method has found useful application, particularly

where the motor must start and stop frequently under load, and where, as it is operating but a short time, good efficiency is not essential. This method is simply an extension of the method of starting by the use of resistance; but since the resistance is kept in circuit for a longer or shorter time, it must be large enough to dissipate the wasted energy. The loss in this way will, in general, be proportional to the decrease of the speed from the normal.

Induction motors have now been used for a long enough time to demonstrate their reliability. There is probably no other type of motor which requires less attention than does this. For this reason the motor can be mounted in any part of the room—on the ceiling or wall, well out of the way. It should, however, be protected from loose objects, as should any other moving mechanism.

The Power-Factor.

An objection frequently raised against the induction motor is its power-factor. By "power-factor" is meant the ratio of the true power taken by the motor to the apparent power, computed by multiplying together the current and voltage as found from instrument readings. This ratio in general is less than unity, and varies somewhat with the size of the motor. With large motors it may be 0.9 or more, and with very small motors, considerably less than this. This means that the motor draws a larger current from the circuit than would an equally efficient direct-current motor, operating on a direct-current circuit at the same potential. The line loss, which depends upon the current, is somewhat greater, and the output of the generator, which is also limited by the current, will be less on an inductive coil—as this type of load is called—than on a non-inductive load. This type of load, furthermore, impairs somewhat the regulation of the generator, and may cause flickering of incandescent lamps when operated from the same circuit, unless means is taken to prevent this. For this purpose static condensers have been used to some extent, but they are not entirely satisfactory for all conditions of load. The desirability of improving the power-factor has resulted in the development of several types of induction motor in which the power-factor can be made to approach unity. These types, however, involve the use of a commutator, so that in this respect they present no advantages over the shunt motor, except in their ability to operate on an alternating-current circuit. An extension of this type has resulted in a motor giving a variable speed. The machine, however, is in an experimental state at this time, but is being watched with interest. The power-factor question is one which has been discussed more or less energetically; but while an improvement in this respect would unquestionably be desirable, provided this did not involve other disadvantages perhaps more serious, the objections to this characteristic of the motor have been rather overdrawn by advocates of the shunt motor.

ELECTRIC POWER IN THE IRON AND STEEL INDUSTRIES.

BY GEORGE E. WALSH.

Electric operation of tools, cranes, locomotives, pumps, and general machinery in the iron and steel industries depends for its success upon the relative cost and efficiency in conjunction with the simplicity and ease of handling. Without compensating advantages, iron and steel mills, foundries and forges are not apt to modify their form of power, or even to equip a part of the plant with new motive power. The designers of electrical equipment for such plants must consequently take into consideration the value of space at their disposal, the cost of operating a great number of machines in series or singly, and the advantages derived from operating new labor-saving machines by simply running trolley wire to them from some outside or central power station.

The designing and adoption of new appliances for doing the work of man have marked the advance of our steel industries to such an extent that a plant to-day is totally different in construction and operation from one built a quarter of a century ago. The tearing down of old mills to make room for new devices to save time and labor is nothing uncommon in the great Pennsylvania iron districts. As a result of this very American method, the fine Homestead mills produce to-day as much fine steel with 4,000 men as the great Krupp works produce with 15,000 men. It is in operating these new devices for saving time and labor that electricity is to-day making itself felt most conspicuously. In the Homestead mills three men will operate a charging car filled with ore or melted steel, working it electrically so that the furnaces can be charged or emptied within a short time, and practically doing the work of nearly two hundred men, according to the old system. The electric charging car goes from one furnace to another, tending without trouble or difficulty a series of twenty furnaces. This simple device was invented as the result of a study of the conditions which called for some method of relieving the workmen of the hardest part of their labors in the hot steel mill.

Near some of the big furnaces there are mechanical stokers electrically operated, which make it possible for one man to do the work of ten without stirring from his position. By means of levers and handles within his reach he is enabled to stoke the fires better than ten men could with shovels and tongs. At the Homestead mills a dozen new appliances have been in operation to save time and labor, and the electric motors controlling them are installed to work out the greatest amount of economy and efficiency of mill operation.

At the Carnegie blast furnaces, where nearly two thousand tons of pig-iron are produced in every twenty-four hours, the work has been reduced to a mechanical science, so that parts of the plant look fairly deserted. Instead of rows and groups of grimy-garbed workmen, one sees two or three men moving rapidly along on a loaded truck, which is automatically or electrically operated, and others perched high on some traveling crane or in the pulpit of some electrically operated device for running the ore in or out of the furnace. The furnaces are filled and emptied almost entirely by electric devices, the fires are fed and stoked by similar power inventions, and the blast gases are automatically collected and conducted to gas engines to be burnt over again. From the blast furnaces the metal is taken to other parts of the mill as required in cars, which are operated either by electric trolley wires or by storage battery locomotives.

The improvements made in the iron and steel mills through the adoption of electricity as a motive power for run-

ning the endless number of new devices for saving time and labor are being carried forward to a higher plane every year. The electric locomotive in these large steel plants is a modern convenience which illustrates this point. There are several types of the electric locomotive in use for hauling heavy loads. They are built to run on narrow and standard gauge tracks, and they are operated by overhead wires and by storage batteries. The combination electric locomotive, which can be operated either by the storage system or by wires, is probably the most complete and flexible of engines yet adopted in the iron and steel trade. This form of locomotive carries the battery box overhead, and it is so arranged that it can be changed quickly from the wires to battery operation. More than this, the storage battery can be charged from the wires while still working in the mill. This type of electric locomotive is very convenient and flexible, and performs work in shops where it is not possible to carry heavy wires. Sometimes only a part of the plant is equipped with electric wires, and for fire risks or other reasons another part is not so installed. In such plants the combination locomotive easily passes from wire-fed power to battery operation, making its work in the yard complete and effective.

This type of electric locomotive is furthermore useful, because on account of its heavy weight it can get more power on the rails to pull a large load. The battery weighs five or six tons, and this is placed advantageously over the driving wheels, so that the wheels will not slip so easily. The power obtained on the rails in this way is sufficient to make the draw-bar pull large. The draw-bar pull of the electric locomotives is generally estimated at one-fifth the weight on the drivers, and consequently by having the six-ton battery over the wheels the actual pull of the locomotive is considerably increased without adding any ballast whatever. In the old type of motors the ballast added represented a considerable load.

The handling of coal in iron and steel mills of Pennsylvania by means of ingenious electrical contrivances is another improvement that has come into vogue within the past few years. The rapid handling and breaking up of coal is obtained by means of a machine which will take complete charge of fifty tons or more per day with the minimum of labor. There is an elevator to haul the coal up to the desired position, and this is dumped by the man in charge by simply touching a lever. Before it is carried up on the elevator it passes through a coal breaker which pounds it to the desired size. This breaker can be regulated so that any size of coal will be produced. The breaker and elevator are operated by the same machine, and the two work in such harmony that there is little need of a superintending power to watch it. The automatic working of the coal breaker and elevator goes on steadily after the gearing has once been set for the day's work. The feeding of exactly the right size coal to the furnace is thus always assured, and there is no risk of mixing small and large size not suited to the grate.

The conveyor belt, which carries the coal from the cars or coal pile to the elevator, or to any desired part of the mill, is operated either by the same motor or a separate one. In fact, where there is a series of furnaces to be fed a conveyor belt is the best means of distributing the coal. In this process the coal is likewise separated and sifted. As it advances along the belt upon an angle of fifteen to eighteen degrees, the small sizes fall through the first series of sieves in the belt, and the next size goes through the second sieve. The distribution of the coal for different furnaces is thus accomplished without any human handling. The whole distribution of the coal supply of a large mill is accomplished automatically, and in half the time formerly required. The motors keep the endless conveyor belt going up the incline so long as coal is needed, but power is shut off the moment the supply is ample.

The installation of the motors for operating the coal breaker and bucket elevators is frequently in places where a great accumulation of coal dust gathers. This spreads all over the motor and almost hides it from sight, but with the working parts carefully protected there seems to be no trouble in operation. Some of these coal-carrying motors have been in operation for years in the iron and steel plants, and beyond requiring a periodical cleaning and oiling they have been of no special trouble. They have performed their work satisfactorily; far better, indeed, than any steam or other power plant could do it.

In a good many of the mills motors have to be installed in positions where they are subjected to intense heat. It was a question for some time in the iron regions whether the motors in such high temperatures could be relied upon. For instance, the motors to-day operating the coke rams are particularly subjected to very high temperature. When the coke oven is opened the heat radiating from it is intense, and the motor in front undergoes a rapid increase in its own temperature. The rams are installed directly in front of the ovens, where they descend and grip the outer sides of the pigs of iron, while a middle ram strikes the blow which shatters the pig into several pieces. Still another ram follows to break the "sow" pieces into smaller pieces. There are several distinct motions in the operations of these rams, but they are all controlled by the one motor, which is coupled to the coal breaker by means of spur reduction gearing. The rapid change of the temperature of the working room appears not to disturb the perfect operation of the motors or the rams, and this fact has proved of great satisfaction to mill owners.

The modern shop cranes operated by electric power are well known for their efficiency and convenience; but in the iron and steel mills they are subjected to strains and tests not found elsewhere. For instance, the very high temperatures in which they have to work at one time, and a comparatively cool air at another, cause rapid expansion and contraction of the metal. The cranes which handle the pig iron operate directly in front of the casting beds. They pick the pigs directly from the casting bed, where the heat is so great that the men can barely endure it for any length of time, and then carry them to the breaking machine or rams near-by. The cranes run the entire length.

Michigan College of Mines.

The legislature of Michigan has passed a bill appropriating $171,900 for the Michigan College of Mines at Houghton for the biennium beginning July 1 next. The most important item of this appropriation is that of $45,000 for the construction of a metallurgical laboratory. The college intends to erect a substantial building for this purpose and to thoroughly equip it for experimental work and instruction in the different classes of metallurgical processes.

Cyaniding and other wet methods of concentration will be exemplified in the equipment and electrometallurgy will receive special attention. It is intended to install furnaces of larger capacity than is usual in college laboratories.

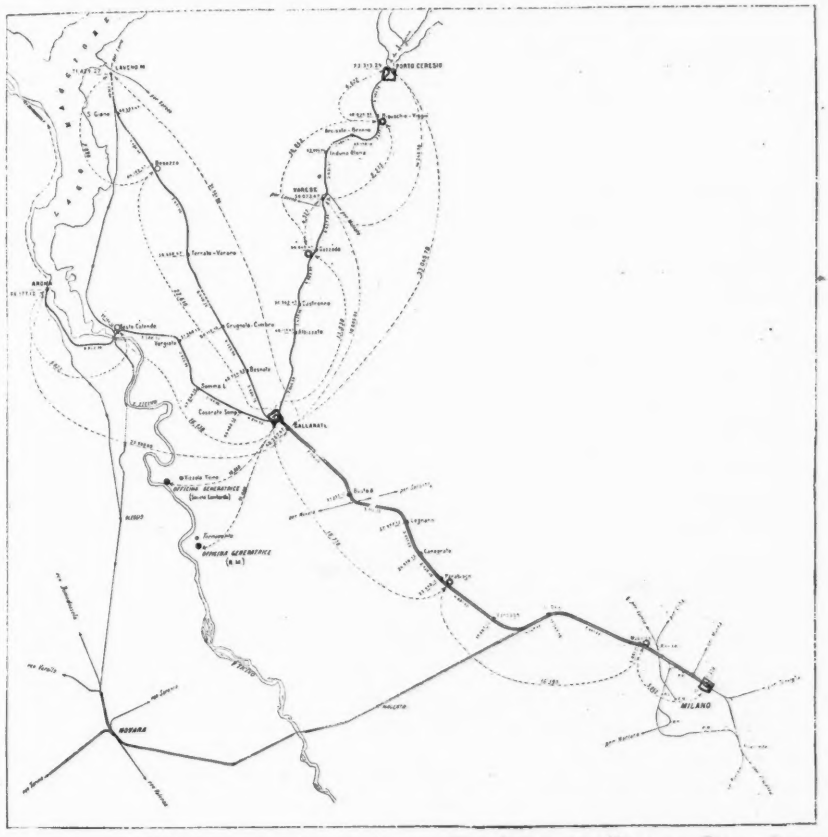
The board of control of the college is taking steps to create a separate department of ore dressing and metallurgy. The equipment for this department will be housed in the new metallurgical building and in the ore-dressing mill now possessed by the college. A man to fill the new chair has not been selected.

Besides the amount for a metallurgical laboratory the bill referred to carries an appropriation of $9,000 for extending the equipment of the department of mining engineering, which now occupies its new building erected last year; $4,000 for completing the equipment of the chemistry building, also erected last year; $2,000 for providing additional cases for the mineralogical museum, and $1,000 for increasing the equipment of the department of mechanical engineering.

The First Third-Rail Electric Railway in Italy.

By Enrico Bignami.

THE decision to extend electric traction to the Gallarte-Arona and the Varese-Laveno branches, thus completing the system of the Varese Railway, shows that the results of this experiment have been such as to encourage its promoters, and it is therefore worth while to describe this system fully. The main line only, from Milan to Varese and Porto Ceresio, has already been transformed. This line is seventy-four kilometres (forty-six miles) in length. The third-rail system has been adopted on this road, this being its first practical application in Italy. This test is more interesting because the application of electricity to traction on steam roads has generally been dictated by peculiar conditions, such as suppressing smoke in the case of cities and on lines with long tunnels; in cases of rapid and dense traffic, caused by the junction of tramway lines, and where the use of steam locomotives is impossible on account of the adherence required on certain mountain lines.



MAP OF THE VARESE RAILWAY SYSTEM, ITALY. THE LINE FROM MILAN TO PORTO CERESIO HAS ALREADY BEEN ELECTRIFIED.

While the Société des chemins de fer Méridionaux has adopted a three-phase system at 3,000 volts on the Valteline Railway, for operating the car motors, the Société des chemins de fer de la Méditerranée has preferred a third-rail system for the line, supplying the motors with continuous current at 650 volts for the Varese lines.

This system has not been applied on these lines without difficulty by the Società delle Strade Ferrate del Mediterraneo. Among other things, a great number of precautions to prevent leakage to the earth were thought necessary on account of rain and snow. Experience, however, has shown that these precautions were unnecessary. The losses, under the most unfavorable conditions, have been limited to one-tenth of an ampere per kilometre, making the total loss on the Milan-Porto Ceresio line not more than eight amperes for the seventy-four kilometres.

The railway system which this company intends to operate by continuous current includes a double-track line from Milan to Gallarate, and three lines connecting Gallarate to Porto Ceresio, Laveno and Arona. The total length is 130 kilometres (eighty miles). The electrical energy is furnished by a central station in the form of three-phase current at 13,000 volts, and is transformed in substations into continuous current at 650 volts, and supplied to the cars by a lateral third rail. This is, indeed, a system adopted to-day for operating tramway lines of some importance. The opening quite recently of the Milano Gallarate-Porto Ceresio section gives opportunity to indicate in detail the manner in which this system has been applied to railways.

From Milano to Gallarate the line is forty-one kilometres (twenty-five miles) long, with a continuous up-grade, the maximum grade being six in 1,000, and the mean grade, two in 1,000. There are very few curves, and the minimum radius is 800 metres. This line serves a populous industrial country, which has frequent communication with Milan. Indeed, the various districts of Musocco, Rho, Parabiago, Legnano, Busto, and Gallarate, which are encountered on this system, may be considered as spokes of a wheel, with their centre at Milan, and where industry flourishes and is constantly developing and increasing.

From Gallarate three branches separate, which serve the lakes of Majeur, Varese and Lugano, and which have their terminals, respectively, at Arona, Laveno and Porto Ceresio. These branches are twenty-six, thirty-one and thirty-three kilometres in length, respectively. They encounter grades varying from eight to twenty in 1,000, and curves with a minimum radius of 300 metres. The travel of passengers during the bad season is light, but is very dense in the summer and autumn, the seasons most favorable to traffic on the lines terminating at lakes Majeur and Lugano, which serve a pleasant country dotted with villas, where the Milanese go to seek quiet and vivifying air, and which is visited by large numbers of foreigners. The line extends at present to Porto Ceresio, but, as has been said, electric traction will be extended to the Laveno and Arona branches. Conditions for the economical conversion of this system are very favorable. Nevertheless, it would be hazardous to make predictions before having consulted financial reports for the year of operation. It may be stated, however, that the problem from the point of view of difficulties and tech-

nical questions which were encountered has been solved successfully.

The passenger trains are composed of two cars only, one being a trailer. Trains run very frequently in both directions on the forty-one kilometres of line which separate Milan from Gallarate. This distance can be covered in thirty minutes by through trains, as car motors with a speed of 100 kilometres per hour have been provided.

GENERATING STATION.

The energy necessary for operation is furnished by a central station at Tornavento, on the left bank of the Tessin, a beautiful river which forms Lake Majeur, and which itself flows into the Po, and where it is intended to develop the necessary hydraulic power. Water is taken from the discharge of the industrial canal of the Società Lombarda, which has at Vizzola an electrohydraulic installation of 23,000 horse-power. By means of a dam in the river, and movable weirs, regulating gates and locks for navigation, the water is supplied to a canal three kilometres long, running to Tornavento. For the first twenty-five hundred metres the canal is protected on the right against overflows of the river by a levee, which is at least one metre above the level of the water. Along its course the canal is raised, with the exception of a short stretch beyond the station. A flow of 105 cubic metres and a fall of 7.85 metres make available 8,000 horse-power. At the hydraulic station there is also a steam plant which will furnish the electrical energy necessary until the hydraulic plant has been completed, and which will be used as a reserve to ensure continuity and regularity of service in spite of all interruptions at the hydraulic station.

All of the mechanical apparatus at the steam station—boilers, pumps, economizers and engines—has been constructed entirely in Italy by the house of Franco Tosi, of Legano, which has again added to its reputation by this installation. The electrical equipment of the station—alternators, switchboards and necessary accessories, exciters, etc.—has been furnished by the Compagnie Thomson-Houston de la Méditerranée.

In the engine room three 750-kilowatt three-phase generating sets have been installed, and two continuous-current groups, with a capacity of seventy-five kilowatts, for excitation. These are operated, respectively, by three large Corliss steam engines and two small slide-valve engines. To the latter, which have a high speed, are coupled directly two six-pole generators.

The distributing switchboard at the generating station is composed of ten panels, two for the exciters, three for the alternators, a panel for the entire output, and four feeder panels. There are two panels for each of the double transmission lines, leaving the station for Gallarate and Parabiago.

THE HIGH-TENSION TRANSMISSION LINES.

The three-phase high-tension current is carried to transformer stations by two independent lines. The first runs to Parabiago, nineteen kilometres (twelve miles) from Tornavento, and from here is extended to Musocco. The second passes to Gallarate, eleven kilometres (6.75 miles), from Tornavento, and from there is continued to Gazzada and Bisuschio. Each line is double, that is to say, it is composed of six bare copper wires, the diameter being between four and nine millimetres (160 and 360 mils), and calculated so that the line loss will not exceed eight per cent. Thus, the diameter of the wire is 5.8 millimetres (232 mils) on the Gallarate line, and nine millimetres (360 mils) on the Parabaigo line. The wires are supported on triple-petticoat insulators.

These lines are protected principally in the neighborhood of the substation by Wirt lightning arresters, and are controlled by oil-break switches operated by hand, upon entering and leaving each substation, so as to facilitate cutting any section out of circuit in case of accident. Circuit switches, mounted on poles at various points on the line, enable the location of all faults upon the system.

TRANSFORMER STATIONS.

The transformer substations—as they are called—are five in number on the Milano-Varese-Porto Ceresio line, and are located at Musocco, Parabaigo, Gallarate, Gazzada and Bisuschio. They are spaced about sixteen kilometres (ten miles) apart. In those at Gallarate, Parabaigo and Musocco, the high-tension current passes through double high-potential bus-bars and two oil circuit-breakers, and is carried either toward the primary of the transformers, or toward the starting compensator, if it is necessary to start the rotary converters from the alternating-current side.

In each of the three substations mentioned above there are seven static transformers with forced ventilation, one of these being held in reserve. These are for twenty-five cycles, having a capacity of 180 kilowatts each, and lowering the potential from 12,000 to 420 volts. From the secondary of the transformers, current passes to the rotary converters, and is transformed into continuous current at 650 volts. Each of the three substations contains two rotary converters, the capacity of each being sufficient for ordinary demands. The second machine provides against accident to the first, and is used at times of heavy demand. They are of two types—500 and 250 kilowatts.

THE CONTACT AND TRACK RAILS.

Contact Rails—The continuous current furnished by the rotary converters, after passing through the switchboard containing the distributing and measuring apparatus, is supplied, by means of insulated cables, to the service conductor. The latter consists of a contact or third rail placed on one side of the way, 675 millimetres (twenty-seven inches) from the track, and raised above the latter 190 millimetres (seven and one-half inches). On the main line from Milan to Gallarate, the contact is placed between the two tracks, instead of on the outside. The rail is of the Vignole type, of Martin steel, with a double head, and is in lengths of twelve metres, weighing 45.5 kilogrammes (100 pounds) per metre.

The rail is supported about every four metres on insulating supports of artificial granite mounted by a cast-iron cap, specially designed and made for this installation. This type of insulator possesses remarkable properties of strength and insulation, and has given satisfaction as well under test as in practice. The rail rests on the iron cap of the insulator so as to allow free motion due to contraction or expansion caused by variations in temperature, or due to the slight vertical motion of the insulator when the train-wheels depress the tie upon which it is fixed.

The third rail, not having to support a great pressure, a fish-plate 200 millimetres (eight inches) long, held by two twenty-five-millimetre (one-inch) bolts, maintains a uniform surface of contact. The electrical continuity of the contact rail is obtained by flexible rail-bonds formed of a small copper plate, terminated by heads of a larger diameter, which enter into holes in the rails. Electrical contact is assured by a pin forced into these heads.

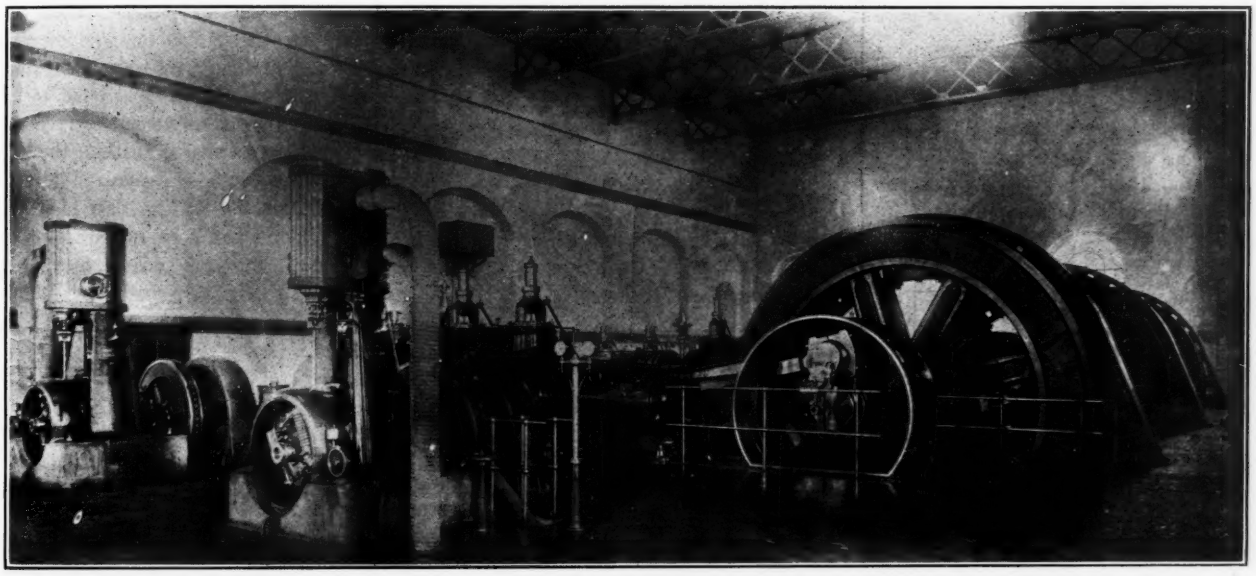
To avoid creeping on inclines, the rails are solidly connected and anchored at the middle point of the tie rod. Movements due to expansion and contraction, caused by variations in temperature, being considerable on account of the length of the way, special flexible connections are placed at the end of each section, thus allowing of sufficient play.

On the main line from Milan to Gallarate, where the track is double, the two contact rails are connected across every 100 metres by bonds eleven millimetres (440 mils) in diameter. At switches and all crossings, and generally in places where the contact rail is interrupted, continuity of the circuit is maintained by an armored underground cable 400 square millimetres in section. On the main lines there are two cables, one acting as a reserve. On the secondary lines, on the contrary, one cable only has been provided. This cable is insulated for 650 volts. It has a double protection formed of a sheathing of lead and an armor of iron ribbon. The cross-section of the copper is 150 square millimetres. At points of attachment to the rail, special terminals have been provided, enclosed in protecting boxes of hard rubber.

Section interrupters for the contact rail are composed of a switch and protecting box of cast-iron, mounted on a pole support; four cables, each ten metres (forty feet) long and 150 square millimetres in section, and an insulating piece of paraffined wood, the latter insulating pieces allowing the section on either side of the switch to be cut out of circuit.

For distributing the energy on the line no feeder is used, the substations supplying the current directly to the contact rail. The latter is interrupted at each substation, and current is supplied to each side of this point by a feeder panel. In this way all substations operate in parallel, both on the continuous-current and on the alternating-current sides; and if, in consequence of a fault, the high-tension circuit at one substation is opened while the continuous-current circuit remains closed, the rotary converters will absorb continuous current from the contact rail and operate as continuous-current motors with series excitation, with the series coils in opposition to the shunt. To avoid this contingency, the continuous-current panels for the rotary converters are furnished with automatic reverse current circuit-breakers, which, by means of an auxiliary bobbin connected in shunt, open the circuit when the current tends to change its direction.

Track Rails—The track is formed of Vignole rails, weighing thirty-six kilogrammes (eighty pounds), placed on cross-ties of wood. Electrical bonding is carried out by copper wires eleven millimetres (440 mils) in diameter and 950 millimetres (three feet) long. At intervals of 100 metres there are cross-connections between the rails of each track and between both tracks.



THE STEAM POWER STATION AT TORNAVENTO, ITALY, SUPPLYING POWER FOR THE VARESE RAILWAY SYSTEM UNTIL THE HYDRAULIC PLANT IS COMPLETED.

ROLLING STOCK.

Motor Cars—The rolling stock, a model of which was shown at the Universal Exposition in Paris, consists of twenty motor cars and as many trailers. They are of the American type, with a frame and car body resting on two trucks by means of double spring suspensions. They were furnished by the house of Miani, Silvestri, Grondona & Comi, of Milan.

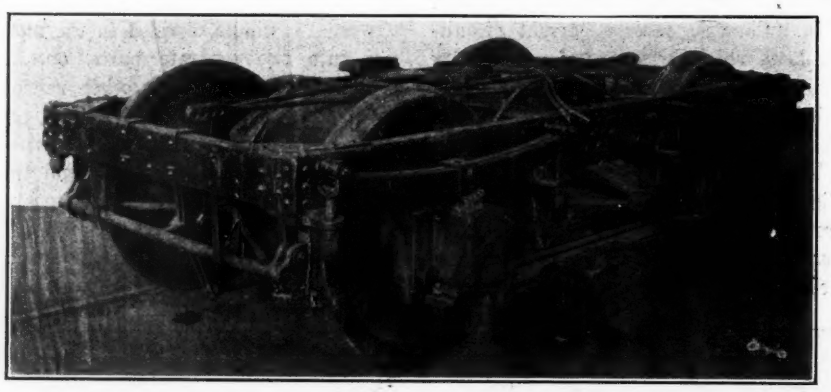
The body has a total length of seventeen metres (fifty-five feet), and a height of 4.145 metres (13.5 feet). The width is 2.96 metres (ten feet) at the central part, tapering to 2.4 metres (eight feet) at the two extremities, where are arranged the motorman's cabs. The cars are subdivided by means of transverse partitions into two first-class compartments, one a smoker, with six seats, and the other with eight seats; and two third-class compartments, one with sixteen seats and the other a smoking compartment with twenty-three seats. At each end there is a covered vestibule, divided in the motor cars into two separate parts, one the motorman's cab and the other reserved for standing passengers. Altogether, each motor can contain seventy-five passengers, sixty-three being seated, and each trailer can accommodate ninety passengers, sixty-three being seated. All compartments communicate with one another by means of sliding doors. The weight of the motor car is forty tons empty, including electrical equipment.

Electrical Equipment—The motor car is furnished with four geared motors, supplied by the Compagnie Thomson-Houston de la Méditerranée, of the type G. E. 55 H, of seventy-five horse-power, but can develop for one hour 160 horse-power without exceeding seventy-five degrees above the temperature of the surrounding air. They can operate in series or in parallel, and have been designed to give the high speed of from eighty-eight to ninety-six kilometres (sixty miles) per hour, and for rapid starting necessitated by frequent stops. These cars have maintained this high speed over a large part of the line from Milan to Gallarate.

Each motor weighs 2,500 kilogrammes (5,500 pounds), and is suspended from one side by bearings on the axle and on

the other side by springs attached to the cross-beam of the truck.

The electrical equipment includes also two series parallel controllers and magnetic blow-outs of the Thomson-Houston L type, each controlling four motors. The electrical equipment is completed by automatic circuit-breakers and all accessory apparatus required for the general security, as well as two lightning arresters.

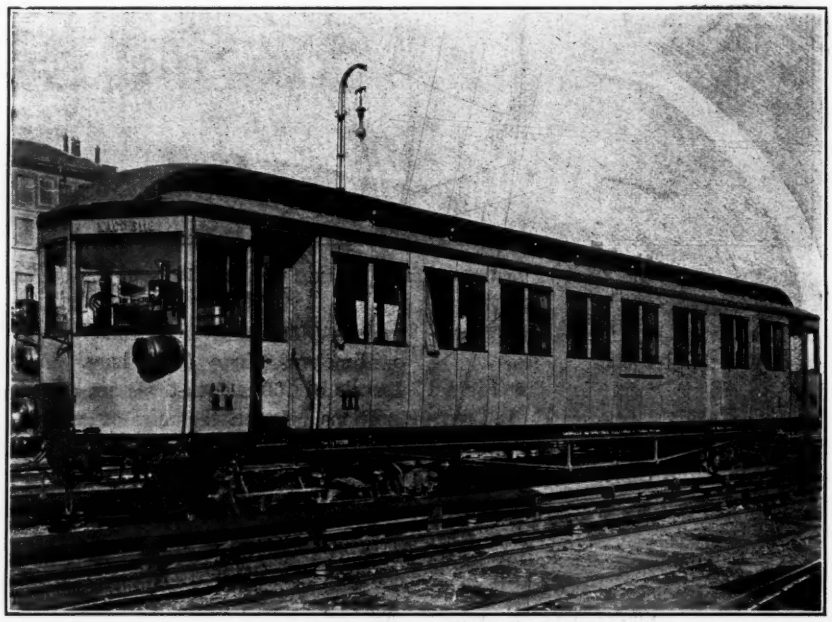


TRUCK USED ON THE VARESE RAILWAY SYSTEM, EQUIPPED WITH TWO SEVENTY-FIVE HORSE-POWER MOTORS.

Each car is also furnished with safety hand brakes and Westinghouse air brakes operated by a pump driven by a small electric motor of four horse-power. The signaling whistle is also operated by compressed air. Excellent lighting is given by incandescent lamps mounted in series on the feeding circuit. Normally, the current is furnished from the third rail, but there is a second series of reserve lamps fed by a small battery of accumulators of the Hensemberger House, of Monza. When, for any reason whatever, the motor car is no longer in contact with the third rail, or when that is without current, the reserve battery is automatically thrown into circuit and the continuity of lighting is thus assured. Nevertheless, by an excessive prudence the front and rear signal lamps are furnished in duplicate by oil lamps, so as to protect the cars against all accident. The cars are heated electrically, and during the past winter this gave entire satisfaction.

Current is collected by four contact shoes, two on each side of the car, for the contact rail is placed sometimes to the right and sometimes to the left of the way, on account of the position of the platforms, changes in the road crossings, etc. The contact shoes are placed at the extremities of the car, and spaced ten metres apart, thus assuring constant contact even in places where the contact rail, placed on only one side of the road, is interrupted, as, for example, at switches and grade crossings. At certain points breaks in continuity are greater than ten metres, but this has not given any trouble whatever.

Trailers—These cars were furnished also by Miani, Silvestri, Grondona & Comi, of Milan. They, too, are of the American type, with central aisle and trucks, quite similar in all points to the motor cars, except, naturally, the motorman's cab is not present. They have also larger vestibules which accommodate more standing passengers. The trailers have Westinghouse air brakes operated by the motor car, and a safety hand brake.



MOTOR CAR ON THE VARESE RAILWAY SYSTEM, ITALY, CENTRAL AISLE, SEATING SIXTY-FIVE PASSENGERS.

They are also lighted and heated electrically, drawing their supply from the motor car. They are furnished with a battery of accumulators and a series of reserve lamps, so as to maintain the lighting when they are detached from the motor car. This happens frequently, even in normal operation, because to avoid the annoyance to the passengers of transferring, several of these cars trailed electrically from Milan to Gallarate or Varese, are drawn by steam up to Arona, and for the past year to Porto Ceresio, until the main line had been completed. The motor cars, on the contrary, do not run beyond the lines operated electrically, because of the projection of the contact-shoes. Movable shoes could be provided, which would give the cars full liberty, but at the present time this does not seem necessary. On the other hand, when it is necessary, the shoes are easily and rapidly dismounted. The weight of the trailer is about thirty tons.

Standard Train—One motor car and one trailer form the train type, which may be called the standard train, planned for the Varese lines. It weighs, empty, sixty-five tons, and, full load, a little over seventy-five tons. The motive power has been calculated to give speeds of ninety kilometres (sixty miles) per hour, a speed which has even been surpassed in certain tests; but, by excessive caution, the speed was limited to seventy-five kilometres (forty-six miles) for the first months of operation, but has been raised at present to eighty kilometres (fifty miles), and will soon be carried to the ninety planned for. The motor car is somewhat elastic, and by reducing its speed a considerably greater effort can be secured. Thus, at eighty kilometres (fifty miles) it can trail ninety tons, including the motor car, and at sixty kilometres (thirty-seven miles) it can trail 104 tons.

Electric Locomotive—The nature of

the movements of passengers on this line, the crowding at certain hours of the day, the necessity of transporting baggage by certain trains, of drawing railway mail cars by others, etc., all require the operation of heavier trains. This is accomplished by an electric locomotive. The locomotive has the usual form, with the motorman's cab in the centre, and cut down at the two ends. It is carried on two trucks, and its equipment includes four Thomson-Houston G. E. 55 H motors, identical with those on the motor car, and with the same capacity of seventy-five horse-power. By a change in the gear ratio, raising this to 3.29, it being 1.96 on the motor cars, the locomotive is enabled to develop a considerably greater tractive effort by running at a lower speed. In fact, at fifty kilometres (thirty-one miles) it can draw 150 tons. Its weight is thirty-five tons.

The normal arrangement of a train drawn by the locomotive is one mail car, two passenger cars of the trailer type described, and two ordinary passenger cars, in all five cars, of 100 tons, which can be increased to 150 tons if the service demands it.

In concluding the description of this system, an important one in every particular for Italy, because of the practical contribution which it will make toward the transformation of the traction systems, even on the large railroads, the following data as to costs are given:

	Francs.	Dollars.
Equipment per kilometre for the third rail	16,500	3,300
Equipment for the third rail, for the seventy-four kilometres	1,221,000	244,200
For the transmission line at about 1,000 francs per kilometre	797,000	159,400

The cost of the substations, taking for an estimate one substation containing two converters of 500 kilowatts each, as this is the case for the substations of Musocco, Parabaigo and Gallarate, will be as follows:

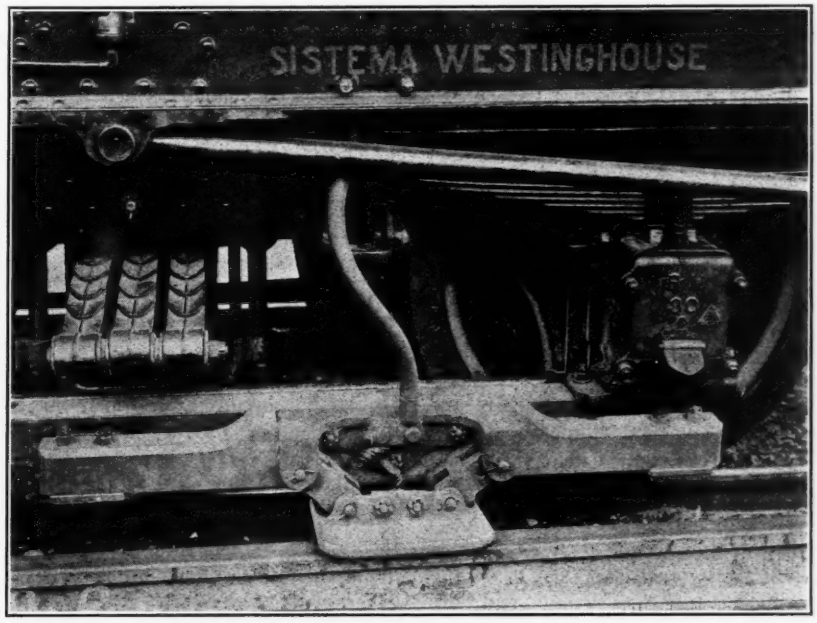
	Francs.	Dollars.
Seven monophase transformers of 160 kilowatts, each twenty-five cycles, 12,000/420 volts; two induction coils, two compensators and two ventilating motors	70,000	14,000
Two six-pole converters of 500 kilowatts, each twenty-five cycles, and an extra armature	90,000	18,000
Distributing switchboard	20,000	4,000
Connections between the high-tension line and transformers, the converters and switchboard	8,000	1.600
Miscellaneous expense	15,000	3,000
Total	203,000	40,600

The two substations equipped with a single converter of 250 kilowatts cost in the neighborhood of 140,000 francs ($28,000) each, or 280,000 francs ($56,000), including the accumulators.

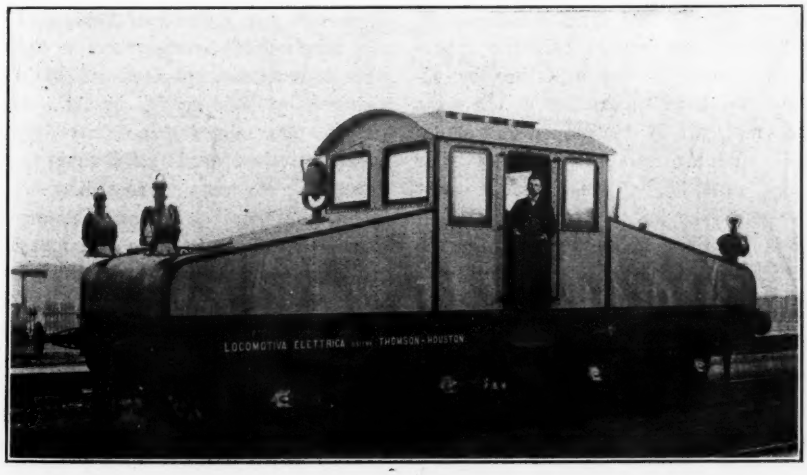
TOTAL COST.

	Francs.	Dollars.
For the third rail	1,221,000	244,200
For the transmission line	797,000	159,400
Three main substations	609,000	121,800
Other two substations	280,000	56,000
Making a total of	2,907,000	581,400

This is to say, the transformation of the system on the Milano-Gallarate-Porto Ceresio line, not including the central station and the rolling stock, cost in the neighborhood of 39,000 francs ($7,800) per kilometre.



THE CONTACT SHOE AND THIRD RAIL ON THE VARESE RAILWAY SYSTEM, ITALY.



THIRTY-FIVE-TON ELECTRIC LOCOMOTIVE FOR THE VARESE RAILWAY SYSTEM, ITALY.

When the system is completed, all the hydraulic power used, and the entire installation transformed so as to make possible electrical transportation, even of merchandise, by allowing for interest and depreciation during operation, one will have very safe data for pronouncing on the financial side of the application of the third-rail system to traction on lines which are important, but have different traffic conditions.

Shad for Electrical Men.

Mr. Chas. E. Trump, president of the Novelty Electric Company, Philadelphia, Pa., gave a planked shad dinner to several of his New York friends on Thursday of last week. The fish were caught at Washington Park below Philadelphia and planked in plain view of the guests and eaten with a keen relish by the visitors.

Among those present, besides the host, were Mr. William Carpenter Woodward, of Providence, R. I.; Mr. Ellis B. Baker, of New Haven, Ct.; Messrs. W. L. Candee, George T. Manson and W. H. Hodgins, of New York city. Ex-Senator W. J. Thompson, of New Jersey, who is proprietor of Washington Park and the electric railways running thereto, was present during a portion of the feast.

It was voted unanimously by all the guests to have the event a regular feature annually hereafter, and if Mr. Trump's consent can be obtained, the shad of the Delaware will undoubtedly be depleted to this extent with annual regularity.

THE EXPERIMENTAL BASIS FOR THE THEORY OF THE REGULATION OF ALTERNATORS.[1]

BY B. A. BEHREND.

Many papers have been published by various authors on the theory of voltage regulation in alternating-current machines, but their writers have been sadly in the dark as to the actual facts which a complete theory has to explain. This state of affairs is perfectly natural, as experiments on large modern machines are extremely difficult and costly; and few men have either the patience or the opportunity to carry out series of measurements which can be used as a foundation upon which the theory of regulation can be built. A theory which is not supported by facts is worse than none, and yet without theory it is impossible to design rationally and economically any kind of apparatus. Designers of alternating-current machinery who ten years ago began to develop for themselves the necessary theoretical basis for their designs will, no doubt, appreciate the difficulties which they had in obtaining a clear view of the many conditions to be taken into account in designing alternating-current generators and synchronous motors. And no doubt they will remember that the greatest difficulty which they encountered was the question of how to determine the inductive drop in the armature.

The subject matter of this paper is to supply an array of experimental data obtained on the most modern designs of alternating-current generators. A somewhat empirical theory is given in this paper, which satisfactorily explains quantitatively and qualitatively the observed results; but no attempt is made in this theory to take into consideration the many varying factors that would naturally have to be introduced into a complete theory of the phenomenon of regulation.

The presentation of this paper has been undertaken, partly, with a view to supplying the committee on standardization with data to enable them correctly to draw up rules for the determination of voltage regulation, as section 71 of the Institute rules is, by no means, in accordance with fact and observation. The matter being of extreme importance, the duty devolves upon the designing engineers, who have accumulated experimental evidence, to publish this evidence so as to enable consulting engineers to draw specifications intelligently without asking for physical impossibilities.

[1] A paper read at the 177th meeting of the American Institute of Electrical Engineers, New York, May 19, 1903.

The term "regulation" is vague and has been used very loosely. We understand by the regulation of an alternating-current generator, the increase in per cent of the terminal voltage consequent upon throwing off the load, the speed and exciting current remaining the same. Our problem consists in determining the terminal voltage for any current and power factor for various ampere-turns excitation. In practice, it is difficult to make tests under load, especially on very large units. Therefore, it is necessary to have a method which enables us to determine the terminal voltage for any current and power-factor from tests which can easily be performed. The first attempt to do this was made by Dr. Behn-Eschenburg, of Oerlikon, in 1892. It is a curious coincidence that the experiments which Dr. Behn began and which I continued extensively at the Oerlikon works, were made on types of alternators which bore out and corroborated Dr. Behn's theory, although this theory does not represent the actual conditions on modern machines. The first experiments were made on machines of the Lauffen type, and later experiments were made on machines of the inductor type, both types of machines being carefully designed. Dr. Behn suggested that if the open-circuit saturation curve of the generator was known as well as the current which the machine generated in short-circuit, we could obtain the apparent impedance of the armature by dividing, for a given excitation, the volts on open-circuit by the amperes in short-circuit for the same excitation. This theory, superficially considered, appears very plausible; but it is evident that it throws together, without explanation or justification, the armature reaction and the self-inductive efforts produced by the local fields in the armature. It appears plain that, for all we know, the local fields might be independent of the saturation of the machine, while the effect of armature reaction would, of course, be dependent upon the degree of saturation. The experimental investigation was encumbered by the fact that the power factor plays such an important part in the magnitude of the inductive drop. In order to simplify the conditions, we have only to consider that the drop in an alternator is a maximum if the power-factor is a minimum. It can also be readily shown that if the power-factor is diminished below twenty per cent, the drop will practically remain unchanged, the error being extremely small in assuming that the power factor of twenty per cent or less is equivalent to a power-factor zero, as regards inductive drop.

The alternating-current generators built during the past ten years have had to operate mainly upon induction motor loads. At least this is true in regard to the generators built in the early nineties in Europe, as induction motors were then used on a large scale in Europe. It seemed to me it was logical to demand that a generator should be capable of standing an induction motor load equal to its rated kilovolt amperes. Therefore, all my machines were designed so that they could give their full rated output in kilovolt amperes on a load of any power-factor. These machines were tested by using, as a load, induction motors running idle, so as to be sure that the power-factor would be below twenty per cent. In order to obtain very large currents, I used synchronous motors running without, or with very slight, excitation. The simplification thus obtained in interpreting tests and theory is worthy of notice.

Fig. 1 shows the saturation curves at no load and at ninety-six amperes load, $\cos \varphi < 0.2$, as well as the short-circuit curve of a large inductor generator built six years ago at the Oerlikon works. The magnetic circuit of this machine is represented in Fig. 2.

Applying Dr. Behn's method to these curves and referring to Fig. 3, where OB represents the saturation curve, and OC the short-circuit curve, we find the apparent reactance, neglecting ohmic resistance, by dividing AB by AC. If we wish to determine the inductive drop for a current represented by DE equal to one-third AC, we reason, according to Dr. Behn, that as it takes an electromotive force equal to AB to drive a current equal to AC through the short-circuited armature, it will take an electromotive equal to DF ÷ AC, equal to one-third AB, to drive a current DF through the armature. We thus obtain a point G. BG being equal to one-third AB. Applying the same reasoning to different excitations, we obtain a curve DHG, which represents the terminal voltage at different excitations for a constant current FD at a power-factor zero. Applying this method to Fig. 1, we obtain results compiled in table 1.

In applying the rule of paragraph 71 of the committee on standardization it needs be remembered that, referring to Fig. 3, it takes an excitation corresponding to OD to produce in the short-circuited armature, a current DF. Therefore, following the Institute rule in paragraph 71, in order to get the load saturation for a

current DF on a power-factor zero, we have to deduct the ampere-turns OD from the ampere-turns on open-circuit. The result is curve DIK, the distance between this curve and the curve OLB measured along the abscissa being the same.

In table 1 there are placed, side by side, the actual regulation obtained by experiment and the regulations as calculated from Dr. Behn's method, and as determined by the rule of paragraph 71. The results obtained by the former method are given in column "A"; by the latter, in column "B." It is evident that column "A" gives results which are very nearly accurate, while the error resulting from the use of method "B" is greater than 700 per cent at high saturations. For the straight part of our saturation curve, the above methods give the identical results. For the saturated part, method "B" yields in this case a regulation which is several hundred per cent smaller than the actual regulation, while method "A" yields a regulation which is a few per cent larger than the actual regulation. These tests were made on a large inductor generator with small air-gap and large pole pitch, which are the best possible conditions for good regulation. Fig. 2 shows the number and size of slots and other details.

We will now apply the two methods "A" and "B" to a 500-kilowatt, three-phase generator designed with all the finenesses that can be employed to obtain good regulation with greatest economy of material. The machine on which the tests were made was designed for 400 volts, three-phase, twenty-five cycles and was run at 150 revolutions per minute. The load consisted of rotary converters running without excitation.

Fig. 4 shows the observed data in the form of a curve, while Fig. 5 shows the magnetic circuit. Leaving it to the reader to check the many observed points for himself, reference will be made to a few points to illustrate the argument. For instance, take the point observed at 160 amperes excitation. Here the electromotive force on an open circuit is 512 volts, the terminal voltage at 1200 amperes load cos $\varphi < 0.2$, is 420 volts. The short-circuited current at this excitation is 3,400 amperes. According to method "A," an inductive drop is obtained, equal to $1,200 \div 3,400 \times 512 = 181$ volts; by method "B" 102 amperes excitation as resultant excitation, which corresponds to 448 volts terminal pressure. Hence the following table:

TABLE I.

Amperes Excitation.	Actual Terminal Voltage.	Calculated Terminal Voltage.		Regulation Per Cent.		
		A.	B.	Actual.	A.	B.
10	360	365	356	143	140	145
20	1,110	1,115	1,140	41.5	41	37 7
30	1,700	1,688	1,840	24.1	25	14.7
40	2,100	2,073	2,290	16.6	18.7	7.4
50	2,330	2,300	2,540	13.7	15.2	4 35
60	2,460	2,431	2,700	12 3	13.1	1.85

TABLE II.
Regulation.

Actual. Per Cent.	A. Per Cent.	B. Per Cent.
22	54.5	14 3

The state of affairs in this case has become reversed, and method "A" which gave approximately accurate results on the inductor generator, gives results which are over 200 per cent too large on a well-designed revolving field generator, while method "B" yields a regulation which is about fifty per cent too small. To adduce some further evidence to show the inherent errors of the two methods, there are shown in Fig. 6 the experimental curves taken on a 1,600-horse-power synchronous motor operating on a three-phase system at thirty cycles and 450 revolutions per minute. The magnetic circuit of the motor is represented in Fig. 7.

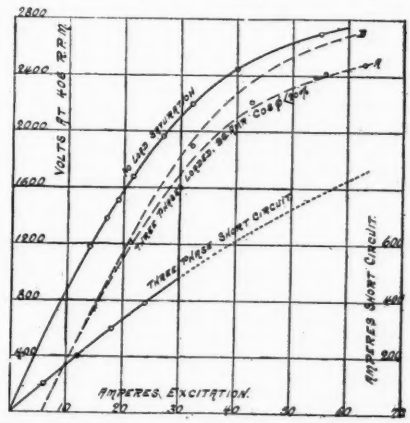


FIG. 1.—REGULATION CURVES ON 500-KILOWATT THREE-PHASE INDUCTION GENERATOR.

Method "A" gives, at 155 amperes excitation, 244 amperes load, a terminal voltage of 2,130. Method "B" yields a terminal voltage of 2,240 volts. The actually observed terminal pressure was 2,130 volts. Now, it is clear that neither method "A" nor "B" yields accurate results in this case, but method "B" approaches somewhat more closely to actual facts than method "A" does. These curves were taken by running the synchronous motor as a generator. The tests were made by taking two machines, one running as generator, the other as motor.

Returning once more to Fig. 3: The writer, some five years ago, named the method "A," which yielded the regulation curve D H G, the "pessimistic method," while he called the curve D I K obtained by applying method "B," or the Institute method, the "optimistic method." These names have since been widely used in European electrical journals. There is some justification in using these terms as, from the standpoint of the designer, the application of method "A," which we will in the future call the "electromotive force method," yields terminal pressures which are much smaller than the ones he will actually obtain, while method "B," which we will call the "ampere-turn method," yields values for the terminal pressure which are considerably greater than the ones he will actually obtain. A machine designed according to the ampere-turn method will give less volts than required, while the machine designed by the electromotive force method will give more volts than required.

Again referring to Fig. 3, it is clear from the evidence so far adduced that the curve for the actual terminal voltage lies between the two curves D I K and D H G; that is, between the optimistic and pessimistic curves. But, further to corroborate this statement, there are shown regulation curves in Fig 9, Fig. 10 and Fig. 11, Figs. 10 and 11 being reproductions of the three-phase and single-phase load curves with the optimistic and pessimistic curves plotted in the diagram. Fig. 9 shows also the electromotive force between the open phase and either of the two terminals of the loaded phase. This curve will be referred to later.

The magnetic circuit of this machine is shown in Fig. 12.

The figure shows the shape of the poles and the shape and size of the slots. The curves in Figs. 9, 10 and 11 belong to a generator the normal rating of which is 200 kilowatts at 13,000 volts and sixty cycles. The load saturation was taken by running two of these machines together, one operating as generator, the other as

synchronous motor. The power-factor varied between eight and fifteen per cent. Fig. 10 represents a three-phase load, while Fig. 11 represents a single-phase load. These curves are well fitted to bear out the essential parts of the theory of the regulation of alternators, as they indicate clearly that the armature ampere-turns which are opposed to the field ampere-turns are large in the three-phase machine and small in the single-phase machine; while the electromotive force produced by local armature fields is small in the three-phase machine and large in the single-phase machine. These conditions result in the load saturation curve of the single-phase machine lying very close to the pessimistic curve, while the load saturation of the three-phase machine lies about half way between the optimistic and pessimistic curves. These diagrams indicate the armature reaction separated from the self-inductive effect of the local armature fields. The side of the triangle which is parallel to the abscissa represents the armature reaction, and the side parallel to the ordinate represents the self-inductive effect of the local fields. From the curves in Figs. 10 and Fig. 11 it is seen that by resolving the total inductive drop into such components results are obtained which are very closely in agreement with actual observation. However, there remains the difficulty of separating these two components. We add Fig. 12 to our experimental data, representing the regulation curves of a 100-kilowatt, 900 revolution per minute, 60-cycle, three-phase generator, the magnetic circuit of which is represented in Fig 13. The curves contain a no-load saturation; a saturation curve for thirty amperes three-phase load of low power-factor; a saturation curve for thirty amperes, single-phase load, low power-factor; a curve giving the voltage between either one of the two phases operating single-phase, and finally the three-phase and single-phase short-circuit curves. It need hardly be remarked that the single-phase curves were obtained by operating two phases of the Y-connected machine in series. The curves in Fig. 12 are condensed in table III.

A glance at this table shows that as soon as the saturation of the machine begins, the ampere-turn method, which is embodied in the Institute rule, gives results that fall very far from the mark. For instance, we observed at twenty-eight amperes excitation a regulation of 28.2 per cent, while we calculated only 16.8 per cent. At thirty-two amperes excitation the case is even more striking, as we observed twenty-two and one-half per cent regulation against twelve per cent as calculated.

In Fig. 14 are given the regulation curves of a 350-kilowatt, two-phase generator operating at sixty cycles and 600

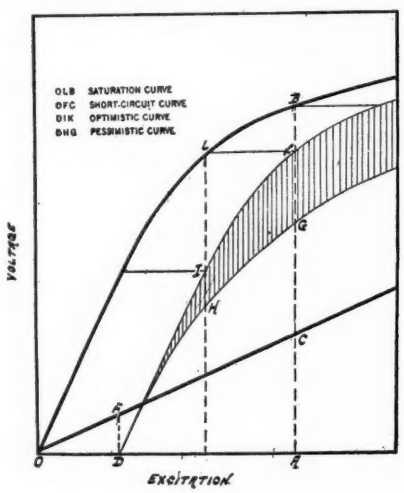


FIG. 3.

revolutions per minute. This figure also contains the curves for single-phase load. The magnetic circuit of this machine is shown in Fig. 15. I want again to call attention to the fact that if these curves are checked by the two methods mentioned in this paper, we find that for two-phase and three-phase machines, the curve of the terminal voltage lies between the two curves termed the optimistic and pessimistic curves, while the single-phase load curves approached very closely to the pessimistic curve.

The data of Fig. 14 are represented in table IV which, after what has been said, require little comment.

This table shows conclusively that on most modern machines the Institute rule gives results which do not at all correspond to actual observation.

It has been demonstrated by the large number of tests described in this paper that the "ampere-turn" method does not give satisfactory results in determining the regulation of an alternating-current machine. The method is inherently wrong, as it neglects the extremely important inductive effect of local fields in the armature. It has also been shown that the electromotive force method gives entirely misleading results. Therefore, it is proved conclusively that it is not possible to obtain regulation of an alternating-current machine by using no other characteristic than the saturation and short-circuit curves.

Another element is required in order to enable us to resolve all the effects of the armature current into two components, one component representing the demagnetizing effect of the armature, and the other component representing the inductive drop produced by local armature fields. Any theory which aims at a complete explanation of the phenomena produced by a load in the armature of alternating-current machines must conform to actual observation and fact. Therefore, the two methods which have been criticised in this paper stand condemned. They should not be used for the quantitative determination of the regulation, because they do not explain nor express the facts. We must frankly admit the existing predicament that there is no simple method which explains all the facts observed, although the designer undoubtedly creates for himself an empirical

TABLE IV.

350-Kilowatt, Two-Phase Generator.

Amperes Excitation.	E. M. F.	Terminal Voltage.	Terminal Voltage Calculated by Institute Rule.	Regulation Per Cent.	
				Observed.	Calculated by Institute Rule.
20	1,700	640	640	166	166
30	2,250	1,440	1,520	56.2	48
40	2,550	2,030	2,160	25.6	18
50	2,775	2,360	2,500	17.6	11
60	2,960	2,600	2,740	13.8	8.1
70	3,140	2,740	2,920	14.6	7.55

TABLE III.

100-Kilowatt, Three-Phase Generator.

Amperes Excitation.	E. M. F.	Terminal Voltage.	Terminal Voltage Calculated by Institute Rule.	Regulation Per Cent.	
				Observed.	Calculated by Institute Rule.
16	2,080	1,050	1,050	98	98
20	2,330	1,530	1,600	52.5	45.6
24	2,500	1,850	1,980	35.1	26.2
28	2,640	2,060	2,260	28.2	16.8
32	2,755	2,250	2,460	22.5	12

method by which he can, within very close limits, determine the actual regulation without every time actually performing the experiment. It is entirely a matter of skillful designing to reduce the inductive drop in a machine. It is plain that it is necessary to avoid any leakage from pole to pole and for that reason it is essential to use large pole pitches; in other words, to place the poles far apart from one another. This matter of field leakage is well brought out by a comparison of the regulation curves of the inductor generator in Fig. 1 with the regulation curves represented in the other figures. The poor regulation of the inductor generator is due to the field leakage between the two inductor horns, producing a counter electromotive force. Speaking from a large experience in the designing and testing of this type, I venture to assert that it is impossible to make these machines so that the load regulation curve lies very much above the pessimistic curve. While it is perfectly possible to build inductor generators with good regulation, this can be done only at the expense of a great deal of material, which fact condemns this type not only from a commercial standpoint, but especially from the point of view of the scientific engineer, whose aim it must be to design machines of excellent properties with the least expenditure of material.

In looking at Figs. 10, 11, 12 and 14, in which the drop in the armature has been resolved into its two components, it is seen at a glance that if we want to take advantage of the high saturation it is essential to reduce to a minimum the local fields in the armature, as this reduces the side of our triangle parallel to the ordinate. As a matter of design, this can be accomplished by using a large pole pitch, narrow armature, and, to some extent, a large number of slots per pole and per phase. The large pole pitch which thus proves so useful has the further advantage of improving the ventilation of the machine, thus leading to cool operation. A large pole pitch makes a ma-

FIG. 13

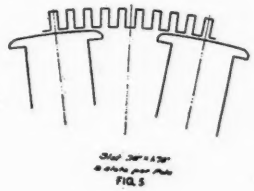


FIG. 5

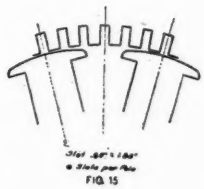


FIG. 15

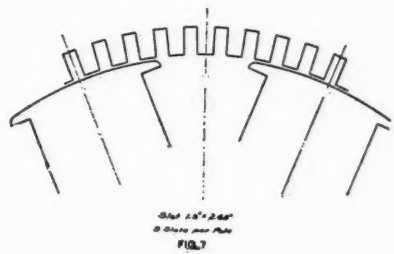


FIG. 7

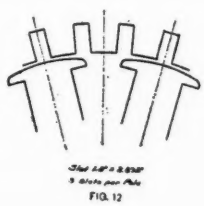


FIG. 12

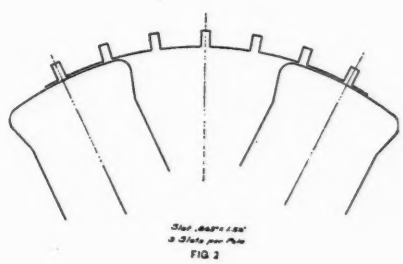


FIG. 2

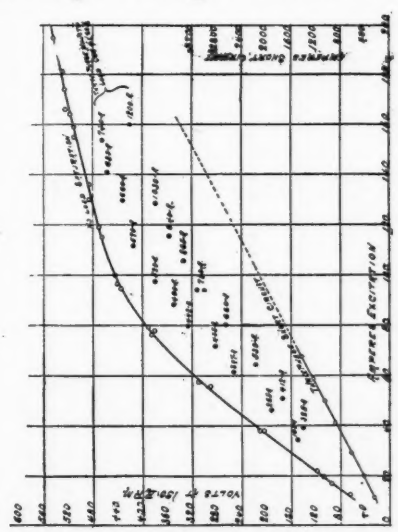


FIG. 4.—REGULATION CURVES ON 500-KILOWATT THREE-PHASE GENERATOR.

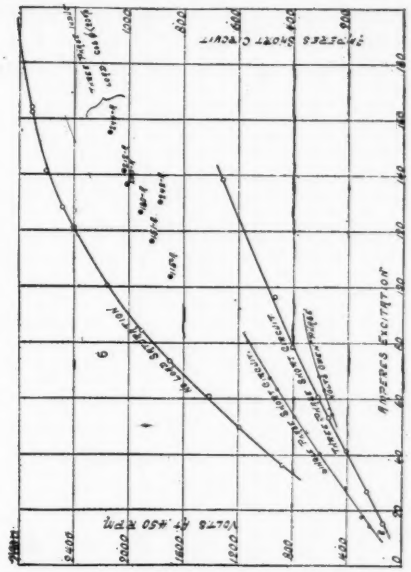


FIG. 6.—REGULATION CURVES ON 1,600-HORSE-POWER THREE-PHASE SYNCHRONOUS MOTOR.

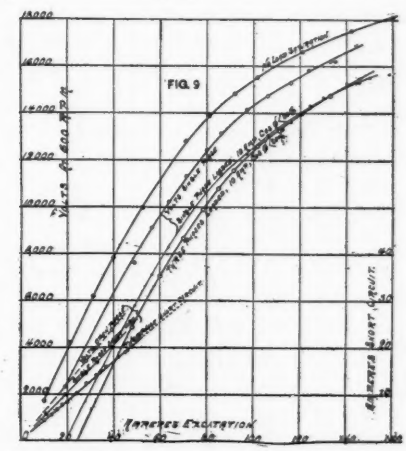


FIG. 9.—REGULATION CURVES ON THREE-PHASE GENERATOR.

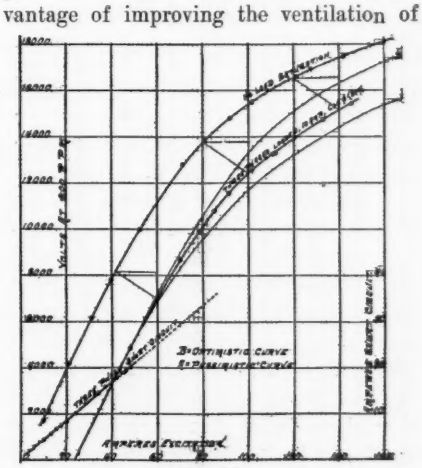


FIG. 10.

chine easily accessible, and increases the radiating surfaces, as the most effective part of the radiating surface of the machine consists of the armature faces.

If for a given certain excitation we have

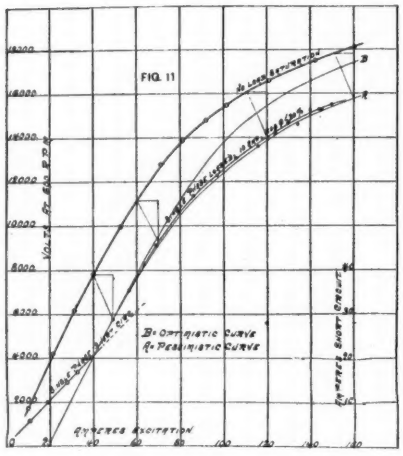


FIG. 11.—SINGLE-PHASE REGULATION CURVE.

determined the drop of a machine for a given current and zero power-factor, we can determine the regulation for any power-factor for the same current, by using the vector diagram. The most elegant method is that represented in Fig. 16, originated by Mr. G. Kapp. After resolving the inductive drop into its two components, the armature reaction and the local fields, we can compose the ampere-turns on the fields OA′, with the ampere-turns on the armature, OA, finding the resultant ampere-turns OC. Next, applying the same process to the local fields, we can draw another diagram, making OB equal the electromotive force produced by these local fields, BA equal to the ohmic drop in the armature, and OA, equal to the electromotive force of the machine produced by the resultant ampere-turns. We thus obtained OC, the terminal voltage of the machine. It can readily be seen that, by describing the two circles with OA′, as radius, about O and A as centres, the radii-vectors drawn from O as centre at an angle $+\varphi$ or $-\varphi$, will intersect the circle of terminal voltage in points C and F, so that OC and OF represent the terminal pressures at the two different power-factors. The quadrant on the left represents a lag of the current, and therefore, a drop in pressure, while the quadrant on the right represents a lead. If the lead increases beyond the point of intersection of the two circles, the terminal pressure rises above the electromotive force of the machine. For most practical purposes it is not necessary to use this diagram twice for the ampere-turns on the armature and for the local fields but it is sufficiently accurate to consider the inductive drop as an apparent impedance and to make OA equal to this impedance.

It should not be overlooked that the apparent impedance is not only dependent upon the field excitation, but it is also dependent upon the armature current. This can easily be seen by working out a few values for the apparent impedance in Fig. 4. It will thus be found that the impedance while a constant at low saturation, increases rapidly with the increase of the armature current at the same field excitation.

It is interesting to study the curves giving the pressure on the open phase while taking out single-phase current, as this has important bearing on the question of regulation of two-phase and three-phase machines when operating on a lighting load. It can be seen from Figs. 9 and 12, which represent three-phase machines, two-phases in series loaded, the third phase open, that for

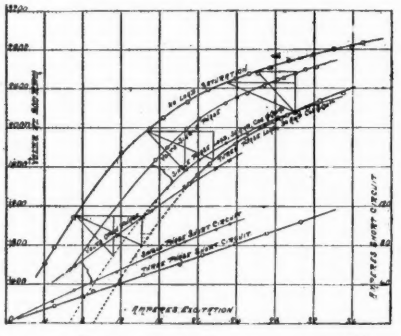


FIG. 12.—REGULATION CURVES ON 100-KILOWATT, THREE-PHASE GENERATOR.

high saturation the curve for the pressure on the open phase between the terminal of the open phase and either of the terminals of the loaded phases lies considerably higher than the curve for the pressure on the loaded phases. The same

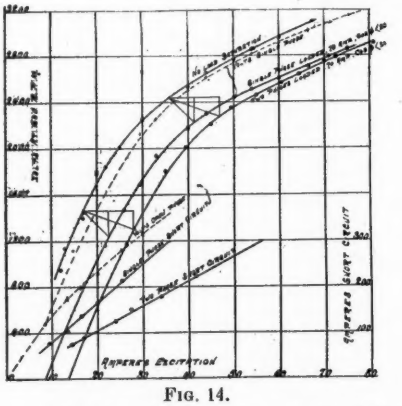


FIG. 14.

is true to almost the same extent of the two-phase machine, the curves of which are represented in Fig. 14. This shows conclusively that there is little preference in favor of either type of machine as far as regulation is concerned.

GENERAL REMARKS REGARDING THE VALUE OF THE SHORT-CIRCUIT CHARACTERISTIC IN DESIGN OF ELECTRIC GENERATORS.

When the use of the short-circuit characteristic is thus greatly invalidated by the difficulty of separating the effects of

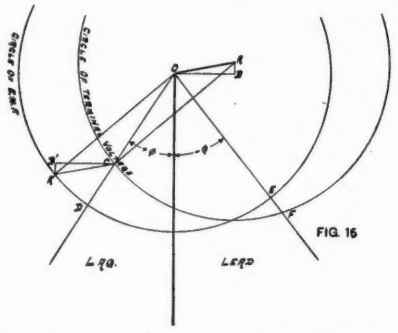


FIG. 16.—KAPP'S DIAGRAM FOR THE DETERMINATION OF THE REGULATION AT DIFFERENT POWER-FACTORS.

armature reaction and of the local fields, it yet remains a valuable characteristic of the machine. It has been shown conclusively in this paper that we can not use the saturation and short-circuit curves alone to determine the regulation of a machine; but it has been indicated that, by plotting from these two curves, two other curves which I termed the "optimistic" and "pessimistic" regulation curves, it is possible, with a certain degree of accuracy, to plot the actual regulation curve between these two last-named

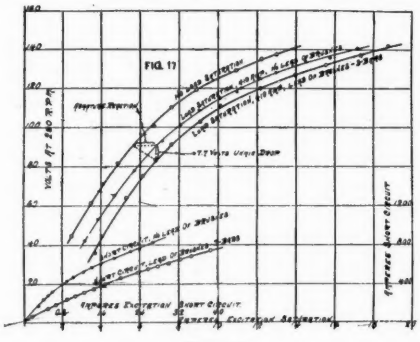


FIG. 17.

curves. In doing this, there is, of course, a great deal left to the discretion and judgment of the designer, who, nevertheless, derives a great deal of help from these curves. The work of designing is more a work of art than a work of science. It is true that sound, scientific knowledge is absolutely required, but scientific knowledge without engineering intuition avails very little and leads merely to abortive designs. The great designers in electrical engineering have not always clearly understood why they have designed a machine in a certain way. They have been guided less by science than by intuition.

The short-circuit characteristic can be

very usefully applied to the regulation of direct-current generators, thus supplying a means of finding the ampere-turns necessary to compound or over compound a machine. Although somewhat foreign to our subject, there are shown in Fig. 17 the saturation, short-circuit and regulation curves of a seventy-five kilowatt direct-current generator. There are plotted in this figure the saturation curve at no load, the load saturation at 410 amperes with no lead of brushes, and the load saturation at 410 amperes with a lead of brushes equal to three bars. There are also plotted two short-circuit curves, one with one lead of brushes, and the other with a lead of three bars. These short-circuit curves have been obtained by separately exciting the generator and short-circuiting the armature. The difference between the ampere-turns required with lead and without lead of brushes at 410 amperes in the armature corresponding to the armature reaction of the machine. It will be found that with no lead of brushes, the distance between the no load and load saturations measured along the ordinate are the same for any saturation, while we can easily determine the load saturation with a lead of three bars, by combining the armature reaction and the ohmic drop in the armature as shown in Fig. 17. The short-circuit test on direct-current machines has the further advantage that it is a rather severe test for commutation, requiring very little power for driving. This method has been used by the writer for testing very large direct-current machines which could not be operated in the testing room under full load. A machine which commutates satisfactorily in short-circuit will surely commutate satisfactorily at full load.

SUMMARY.

To sum up the results of this paper: It has been demonstrated that the application of the ampere-turn method, as proposed by the Institute rules, leads to entirely wrong results. It makes machines of inferior design and large leakage appear in regulation not only equal to, but even better than, machines of careful and superior design. In a word, the method is not scientific and not in accordance with fact and observation.

The ampere-turn method, while very simple, is inherently wrong, and it should, therefore, not be used, even if it is impossible to substitute an equally simple rule for it. The desire to have such a simple rule should not tempt us to adopt one that is false. There is a tendency among engineers to neglect the element of uncertainty which is so prominent in all engineering questions.

In conclusion, I wish to thank Mr. T. S. Allen, one of my assistants, for the pains he has taken in plotting the curves presented in this paper.

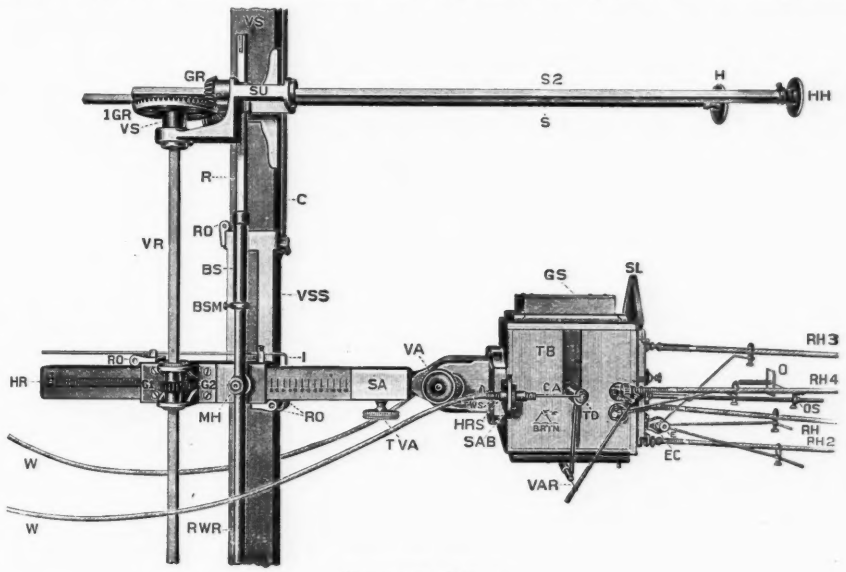
NOTES ON X-LIGHT.

BY DR. WILLIAM ROLLINS.

NOTE CLVI ON SUPPORTS FOR X-LIGHT TUBES.

It is obvious that an X-light tube must have a support to enable its distance and direction from the patient to be varied. The commercial supports being without exception constructed on incorrect principles, fail to meet the conditions of medical, medico-legal practice and those of my method of anthropometrical signalment. A suitable tube-holder will therefore be described and illustrated, which is an improvement on those shown in earlier notes, though constructed on the same general plan to suit the conditions already several times, and now once more, repeated, for repetition is necessary until faulty methods are abandoned. The conditions to be met are:

1. An X-light tube should be in a non-radiable box from which no X-light can escape, except the smallest beam that will cover the area to be examined, photo-



NOTE 156—FIG. 1.

EXPLANATION OF DETAILS NOT MENTIONED IN TEXT.

W—Wires to generator. C—Cord to counterpoise. RH—Handle regulating the size of the opening in the diaphragm plate (refer to the figures in note cxlix for details). RH2—Handle raising or lowering opening in diaphragm plate. RH3—Handle moving diaphragm plate horizontally. RH4—Handle regulating the quality of the X-light by operating the vacuum regulator VAR. O—Orienter (for details refer to notes cxliii and cl). OS—Support for orienter. SL Slide-closing opening in shutter. GS—Slide with transparent non-radiable window through which the X-light tube can be seen. TVA—Screw clamping movement in vertical arc. TH—Terminal plate of the wire W to generator. HRS—Hard rubber sleeve for terminal wire W. SAB—Sliding wooden arm supporting terminal wire and terminal disc (refer to Figs. 1 and 2, note clvii, for details). EC—Support for arm of the regulating handles. E—Clamping screw made on the plan shown in Figs. 5 and 6.

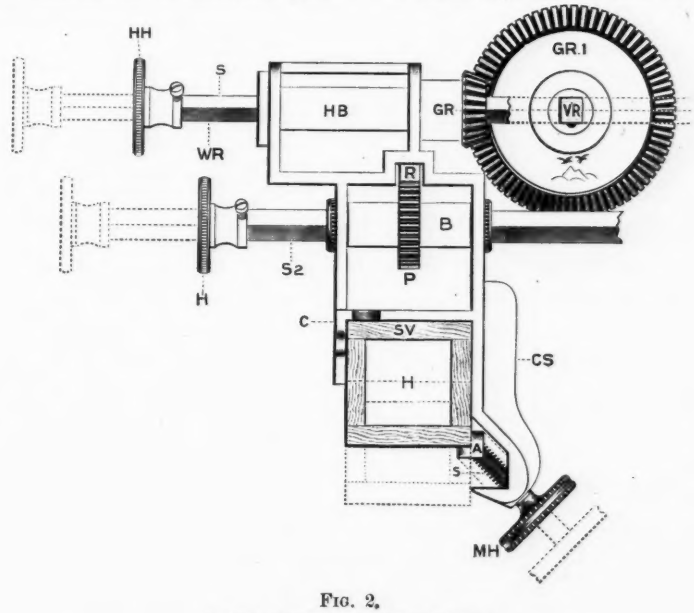


FIG. 2.

Details of support SU shown in Fig. 1.

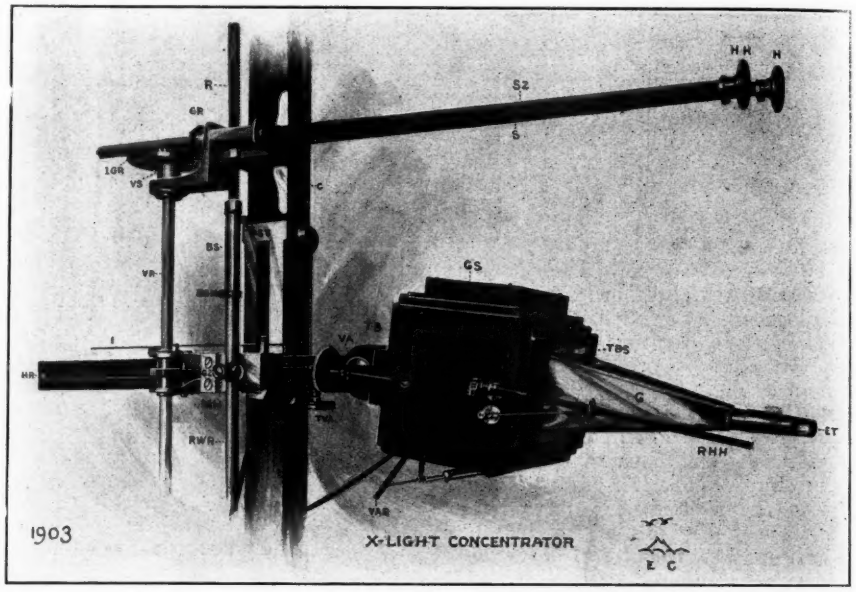
graphed or treated. (First axiom, note cxlviii.) Example showing the importance of this—my experiments reported in the Boston *Medical* and *Surgical Journal* in 1901 and 1902, proved that X-light could burn, make blind and kill animals.

2. The box holding the tube should be attached to a strong upright column to allow the tube to be placed at any height above the floor up to the level of a tall man's head. Example showing the importance of this—a tube is sometimes required to be placed under a patient on a couch, sometimes opposite the chest of a patient in a sitting posture, sometimes above a patient in a reclining position or on a level with his head while standing.

The weight of the tube-box and attachments, about fourteen kilogrammes for the ones shown in my notes, should be counterbalanced by a lead weight, inside the vertical column, that the tube-box may be easily moved vertically and remain in any position, without clamping. This adjustment must be capable of being made when the tube-box is beyond the reach of the observer's arm. (Third axiom, note cxlviii.) Example showing the importance of this—when a tube is at a proper distance, above, on a level with, or below a patient, it is beyond the reach of the observer, yet, as stated in former notes, all adjustments for controlling the light requires to be made under these circumstances. For the vertical adjustment, a handle, H (Fig. 1), projects to any distance required beyond upright column, VS. The distance of the handle from upright column can be varied, as the rod *s* slides freely in the square hole through the shaft B (Fig. 2). The handle H (Figs. 1 and 2) can be placed at any height by means of the support SU, which bears the mechanism through which the vertical and horizontal motions are imparted to the source of X-light. Axiom three showed that all adjustments of the source of X-light must be capable of being made by the observer while looking in the cryptoscope. It is therefore obvious that the position of the handle H must vary through a wide vertical and horizontal range, for sometimes it must be below the source of light and to one side of the examination table, as in Fig. 3, note clv, or below the source of light and the examination table as in Fig. 4, note clv, or above the source of light as in Figs. 1 and 7, note clvi. It is therefore important that the support SU should be easily detached from the vertical support to enable its position to be quickly changed from above the vertical slide bearing the tube-box to below it. Also it is necessary that the means of clamping used should make the support very rigid, as it bears the mechanism through which motion is imparted to the source of light. I have tried several forms of support, finding the one illustrated good. Fig. 2 shows the method of clamping to the vertical support VS. By means of the milled head MH acting on the screw S, the angle piece A is forced forward, pressing the vertical support VS into the angle C of the support SU. To remove the support, the screw is turned in the reverse direction. The dotted lines show how the support can then be freed. To make the vertical adjustment the handle H (Figs. 1 and 2) is turned, imparting motion through the shaft S and the gear P to the rack R, one end of which has a socket BS (Fig. 1) into which fits the wooden rod RWR which is clamped by the screw BSM. The rod RWR passes through a socket attached to the vertical sliding sleeve VSS, carrying the horizontal arm SA of the tube-box TB. The wooden rod RWR can be clamped to the vertical sliding support of the horizontal arm at any distance from the support SU up to 180 centimetres, which is a sufficient range. When clamped, turning the handle H raises or lowers the source of X-light. To make the movements easy, the weight of the tube-box and arm is balanced by a lead weight inside the vertical column VS (Figs. 1 and 2), and two rolls RO (Fig. 1), one at the top, the other at the bottom of the vertical sliding support VSS, reduce the friction.

4. The upright support VS should be securely attached to a firm base, which can be easily moved on the floor in any direction on castors (Figs. 2 and 4, note clv).

5. The tube-box should be attached to the vertical sliding support VSS by a sliding arm SA, as already mentioned, and this arm should be graduated into centimetres on either side of a zero mark 0 (Fig. 1); an index being provided, the point of which can be brought over the zero mark, at whatever distance this may be from the vertical support VS. This horizontal adjustment must be capable of being made when the tube-box is beyond the reach of the observer's hand. (Axiom three, note cxlviii.) The swinging arm which Williams has substituted for the sliding arm is objectionable, for it does not lend itself to this procedure. Example showing the importance of this movement—in examining a pelvis to determine the size of the brim, the tube requires to be moved through a measured distance to bring the source of X-light first directly under one side and then under the other to avoid distortion, for otherwise the width will be recorded as larger than it should be. To get results quickly, means must be provided whereby the changes in the position of the source of X-light can be made without removing the eyes from the image on the fluores-

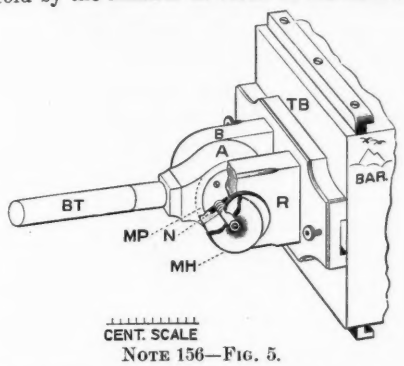


NOTE 156—FIG. 3.

EXPLANATION OF THE ILLUSTRATION.

To the non-radiable tube-box TB is attached a pyramid of non-radiable material lined with zinc which reflects X-light. To the end a lead tube (lined with zinc), with an aperture ET in the side, is attached, through which the concentrated X-light escapes to the part of the body to be treated. A number of ends of different size and shape are required. The quality of the X-light is regulated by turning the handle RHH. The movements described in the text allow the end ET to be brought into proper relations with the patient. For further explanation of the lettering refer to the explanation under Fig. 1 and to the text.

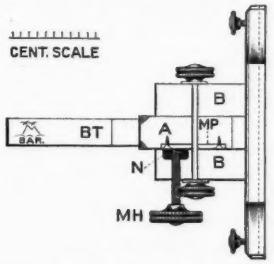
cent screen. The graduated arm taken in connection with my orienter and handles for controlling the movements of the tube enables this to be done. The distance through which the tube is moved can be told by the number of turns of the handle



NOTE 156—FIG. 5.

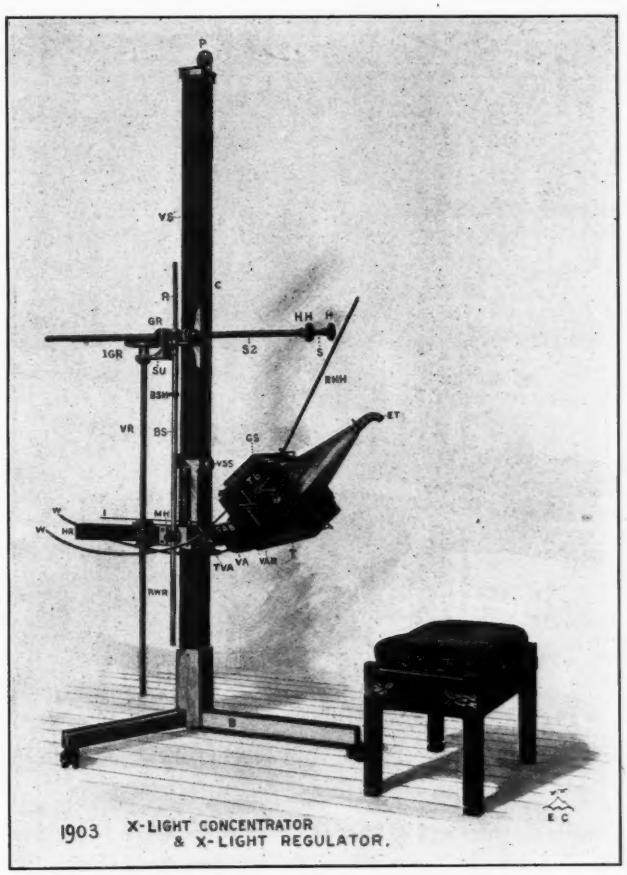
HH (Figs. 1 and 2) or can be read off from the graduations afterward. This handle HH is necessary in making all accurate transverse movements. Rough preliminary movements can be made by having a short track on the floor to engage the castors of the tube support. The castors can be quickly freed from the track when it is necessary to move the tube-stand in other directions. Fig. 1 shows the mechanism of the horizontal motion in detail. Motion of the source of light is imparted through the arm SA by turning the handle HH, which is always within reach of the observer, without removing the eyes from the image on the fluorescent screen. (Refer to Figs. 3 and 4, note clv.)

The square wooden shaft S2 operates the bevel gears IGR and GR. These turn the gears G1 and G2 through the square wooden rod VR. The gear G2 operates the rack HR of the horizontal arm SA to which the tube-box TR is attached.



NOTE 156—FIG. 6.

The rod VR slides freely through a square hole in the shaft of the gear G1, allowing the tube-box to be raised or lowered without interfering with its horizontal motion. To allow this motion to be free, the arm SA moves on the rollers RO. The tube-box should be arranged to turn through two vertical arcs whose planes are at right angles, the axis of one being parallel with the long axis, the other with the short axis of the X-light tube. Examples showing the importance of this—Figs. 4 and 5, note cxxxix; Figs. 3 and 4, note clvi, where the tube is shown in position for treating diseases of the face and mouth. This movement in vertical arc is important when using the light concentrators[1] illustrated in note cxliv and in the present note. Figs. 9 and 10, note cxxxix; Fig. 3, note clv; Fig 7, note clvi, show clearly the importance of having the tube-box turn about an axis parallel to the transverse axis of the X-light tube. Both of these mechanisms I have made capable of being operated, like all the other movements, by means of handles within reach of the observer while making the examination, but as the method—that of worm-gears, increases the cost, I do not illustrate it here. With this method of control no clamping device is required, such as was shown in the figures accompanying this and earlier notes. As the weight of the tube-box and its support were increased, the clamping devices first shown were found inconvenient. A better method, shown in detail in Figs. 5 and 6, was adopted. A steel rod with a milled head at each end for tightening serves as an axis on which the tube-box turns The arm BT ends in a circular piece into which a metal plate MP is set. The milled head MH is attached to a screw which turns in the nut N recessed in one of the projections B-B of the tube-box. By turning the milled head, pressure is made upon the metal plate, thus securely clamping the arm in any position. This may seem too simple a matter to need mention, but where a piece of mechanism is in daily use by a busy man, ease and precision of working are of much importance.



NOTE 156—FIG. 4.

EXPLANATION.

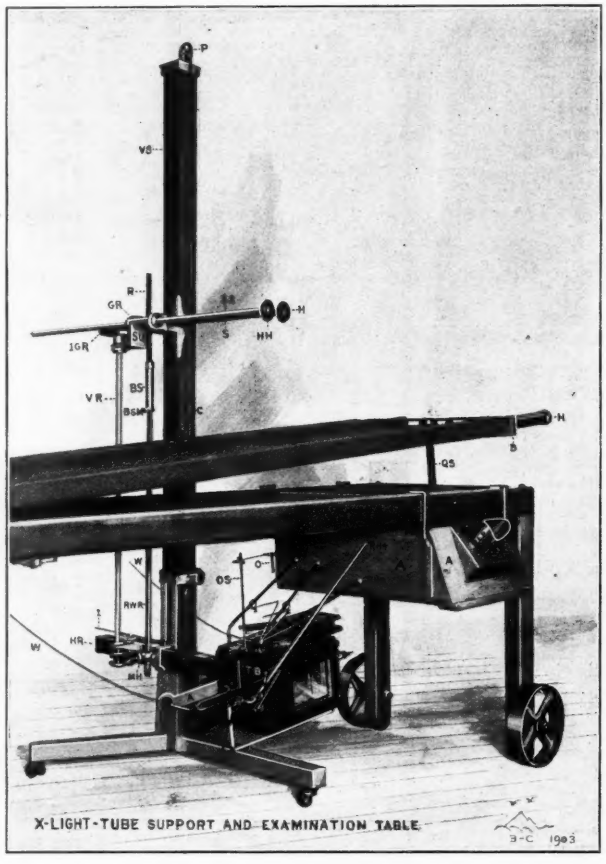
The figure shows an X-light concentrator in position for treating a disease of the mouth. The end ET of non-radial material is placed in the mouth against the diseased area of the tongue. By means of the handles H and HH and the movements in vertical arc (described in the text), the opening in the end ET can be brought into correct relation to the patient, who sits on the stool. For further description of the lettering refer to the text and to the description under Fig. 1.

6. The tube-box should have three rectangular openings, through any one of which X-light can escape for the examination of a patient above, in front, or below the source of X-light. Two of these openings should be closed with non-radiable slides, one of which should be transparent

[1] To further increase the X-light a suitable reflector is placed within the tube-box behind the tube. This reflector may be made of zinc.

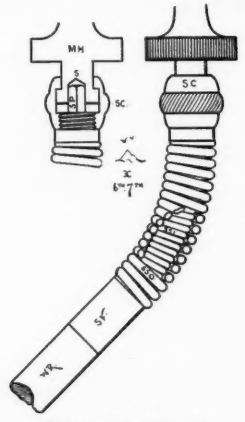
to allow the tube to be seen (Fig. 4, note clv; Fig. 7, note clvi). The third opening should be provided with a slide having a non-radiable diaphragm plate containing a rectangular opening whose size can be regulated while looking at the patient in the cryptoscope in order to reduce the illuminated area to the required extent. (Axiom one, note cxlviii.) This diaphragm plate has already been fully illustrated in note cxlix. Other slides should be provided for the attachments or the light concentrators and light benders shown in note cxliv, note clvi, Figs. 3 and 4. All the slides must be interchangeable that they may be placed at the top, in front, or at the bottom of the tube-box. Figs. 3 and 4, note clv, show the tube-box with the diaphragm plate and shutter arranged for a patient below the source of X-light. The orienter (notes cxix, cxliii, cxlviii, clv, Figs. 3 and 4; note clvi, Figs. 1 and 7) must be mounted on the diaphragm plate in order that their movements may be simultaneously controlled by the observer, who must be able while looking in the cryptoscope to regulate the area illuminated and bring the orienter into position to automatically record on the negative or screen the distance and direction of the source of X-light (axiom four), the angle at which the central ray strikes the screen or plate (axiom five), for all these must be clearly shown on the negative and be seen during the whole of an examination with a cryptoscope if we wish to do our work in a scientific way, for during an examination the amount of light, the relative position of the source of light, the patient, and the cryptoscope need frequent changes.

These plans, which I worked out for a friend some years ago, have never found their way into the standard works on X-light, where less perfect methods like plumb lines are described for adjusting the position of the light in relation to the patient and where no means of making the necessary adjustments of the source of X-light during the examination are given. I suppose the men who write the text-books are so gifted that they are able to achieve results with apparatus which to an ordinary man like myself would prove unsatisfactory. I am convinced that the average physician will always find fluoroscopic examinations so difficult that he will need all the instrumental help he can get; therefore in these later notes, at the risk of repetition, I am describing improved forms of my apparatus which I have been constructing for a friend for use in a small hospital, hoping in this way to meet some of the deficiencies of the text-books on the subject of proper apparatus for fluoroscopic and therapeutic work. When such apparatus is adopted fluoroscopic examinations will become more rapid and more scientific, because more precise.



NOTE 156—FIG. 7.

To show the necessity of having the tube-box turn in a vertical plane about an axis parallel with the transverse axis of the X-light tube. With the stretcher ST tipped as it must be in some cases (see note cxxxix for example) the central ray of X-light escaping from the tube-box and used to take the photograph could not strike the plate normal to its surface without this movement. The tube-box appears to be tipped more than the stretcher, but this is an effect of perspective due to the short focus of the lens which was used in making the photograph. For further explanation of the letters refer to the text and to Fig. 1.



NOTE 156—FIG. 8.

Details of spiral spring connection of the regulating handles shown in the illustrations. There are two tempered spiral springs, one inside the other. The twist is to the right in one and to the left in the other. This allows the regulating handles to be turned either clockwise or counterclockwise without untwisting the springs.

7. The tube-box should be provided with an automatic shutter for instantaneous photography of the chest. A shutter was described and illustrated in note cxxxix. A better, incidentally, in note cxlix, note clv, note clvi. It will be described in detail later, as the present note is far too long.

BOOK REVIEW.

"British Standard Sections." Issued by the Engineering Standard Committee. New York. D. Van Nostrand Company. 9 pages. 9 by 14 inches. Supplied by the ELECTRICAL REVIEW at $1.00.

These specifications have been drawn up by the British engineering societies so as to standardize practice. There are nine specifications given, which include various types of angle irons, bulb tees, bulb plates, Z-bars, channels and beams. Each specification gives a drawing of the material and a table giving the dimensions of the various parts.

Proceedings of the Engineers' Society of Western Pennsylvania.

The March number of the proceedings of the Engineers' Society of Western Pennsylvania contains an article by Professor S. W. Stratton, director of the National Bureau of Standards, upon "Weights and Measures." This gives a brief history of the various standards which have been used in this country, and describes the plans which have been laid by the bureau for establishing satisfactory standards.

POWER PLANT AND SUBSTATIONS OF THE UNITED RAILWAYS OF SAN FRANCISCO, CAL.

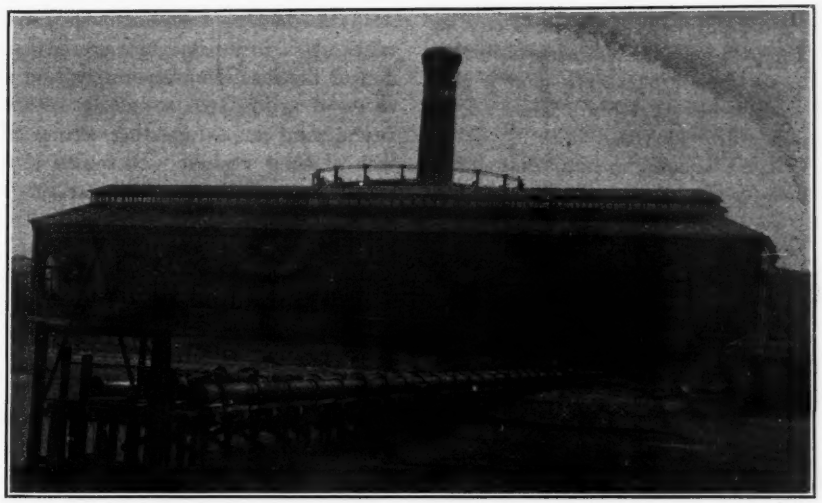
BY FRANK C. PERKINS.

There has been constructed in San Francisco, Cal., recently an immense power-house and substation for the United railroads of San Francisco. Many of the engines, generators and rotary converters have just been installed and others will soon be placed in position. Mr. F. F. Bodler is master mechanic, and the offices are located at Market and Valencia streets. The accompanying illustrations show the new power-house and rotary converter substation. The North Beach power-house is located on the bay and has two large suction condensing salt-water pipes extending far out into the water, and one large exhaust condensing water pipe parallel with the above and at the left. The power-house is of iron and brick construction, and is a model of the latest and best practice in the installation of modern plants.

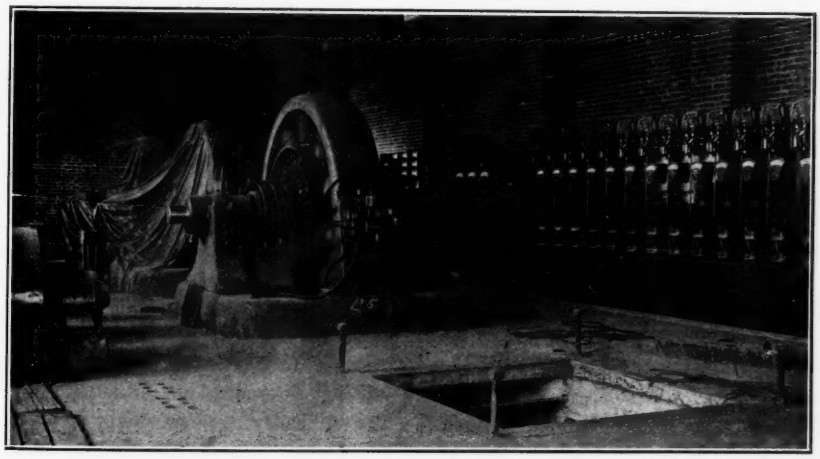
The power units used in this plant have a capacity of 4,000 effective horse-power. The engines are of the triple expansion vertical marine type, and were built by the Union Iron Works for the North Beach power-house. The substation is located at the corner of Turk and Milmore streets, and is also constructed of brick, stone and iron, and represents the latest practice in substation design. The overhead conductors are led from the substation over the main doorway, passing through porcelain bushings in the wall.

The Turk and Filmore street substation has at present installed three rotary, three-phase, direct-current rotary converters constructed by the General Electric Company, of Schenectady. The switchboards are mounted near the wall at the right of the transformers substation, and are equipped with the usual feeder switches, measuring instruments and automatic circuit-breakers.

Only a part of the switchboard equipments has as yet been placed in position and three more rotary converters will also soon be located in this substation. The step-down transformers are of the usual air-blast cooled type, the blowers providing the air being driven by three-phase induction motors. An overhead electric traveling crane is provided in the substation for handling the heavy parts of the rotaries and transformers.



VIEW OF NORTH BEACH POWER-HOUSE FROM THE BAY, SHOWING TWO SUCTION CONDENSING SALT-WATER PIPES ON RIGHT, AND ONE EXHAUST CONDENSING WATER PIPE ON LEFT.



INTERIOR OF TURK AND FILMORE STREET SUBSTATION, SHOWING THREE ROTARY CONVERTERS AND PART OF SWITCHBOARD. THREE MORE ROTARIES TO BE PLACED IN THIS SUBSTATION.

British Railways Bill.

A bill to facilitate the introduction and use of electrical power on railways will be introduced to the British House of Commons by the president of the Board of Trade. The proposed statute consists of seven clauses, the first of which relates particularly to the use of electrical power. This clause authorizes the Board of Trade to make orders for any or all of the following purposes: Authorizing a railway company to use electricity in addition to or in substitution for any other motive power and for any other purpose; authorizing a company to construct and maintain generating stations and other electrical works on any land belonging to the company; authorizing agreements between a company and any other body, or the supply to the company of electrical power, or the supply to or use by the company of any electrical plant or equipment; sanctioning any modification of any working agreement so far as the modification is agreed to between the parties thereto, and is consequental on the introduction or use of electrical power; authorizing the company to subscribe to any electrical undertaking which will facilitate the supplying of electricity to the company; securing the safety of the public; authorizing the use of new capital by the company for any of the purposes of this act; any other matters, whether similar to the above, or not, which may be considered ancillary to the objects of the order, or expedient for carrying those objects into effect. This clause also provides that an order made by the Board of Trade shall have the same effect as if enacted by Parliament.

The second clause relates to power for acquiring land for the purposes contemplated by the bill.

The third clause provides for appeals to the Railway and Canal Commissioners where disagreement arises between the Board of Trade and the company.

The other clauses provide that the Board of Trade must be satisfied that all necessary notices are given to parties concerned, and refer to certain expenses and fees.

The act is not to go into force until January 1, 1904. If this act is passed, it will greatly facilitate the introduction of electricity in railway work, and will reduce the expense to the company by making a private act unnecessary.

TRANSMISSION COMMITTEE.

INTRODUCTIONS TO DISCUSSION, TO TAKE PLACE AT THE INSTITUTE MEETING, NIAGARA FALLS, JULY 1.

The following papers are introductions to a discussion to take place at the Institute meeting at Niagara Falls on July 1. They are not intended to be formal or complete papers, but serve merely as a basis or framework for discussion on the subjects with which they deal.

It should be borne in mind that the introductions are written in order to provoke discussion and that there should be no hesitancy in attacking them if they do not agree with the opinions of the contributor. On the other hand, if the contributor agrees with the matter of the introductions, either as a whole or in part, he should state the fact.

It should also be borne in mind that the principal object of this scheme is to enable and encourage those not in a position to attend meetings to take part in the discussion. If one does not feel himself qualified to discuss certain portions of an introduction, but is able to discuss other parts, it is to be hoped he will contribute to the latter.

Contributions to the discussion of these papers should be mailed to Ralph D. Mershon, 29 Broadway, New York, so that they will be received not later than June 20, 1903.

THE TESTING OF ELECTRICAL APPARATUS FOR DIELECTRIC STRENGTH.

BY P. H. THOMAS.

It is evidently very desirable before depending upon apparatus for commercial service, to have assurance that it is in proper operating condition and also, where the apparatus is built to specification, that the specification has been met. The only practical method of determining the condition of the apparatus as regards its insulation is by means of over-potential tests. This method has been used for a number of years and has been found to be in general quite satisfactory. However, in common with all types of tests which depend upon the application of abnormal strains, over-potential tests have certain drawbacks and involve certain risks. A brief discussion of such objections, especially in regard to insulation tests upon very high-tension apparatus, follows:

(1) A disruptive test fails partially of its object in testing the fitness of the apparatus for actual service, because the conditions of the test do not approximate closely the conditions of the service, either normal or emergency conditions.

(2) Serious injury may be done to the insulation of the apparatus by the test, even under apparently favorable conditions, so that failure may result afterward in actual service.

(3) In making tests on finished apparatus, it is impossible to test each portion of the insulation separately, and the result of many types and forms of insulation being coupled together, is that only that which is weakest with regard to the particular conditions existing at time of test will be tested.

(4) In general, electrical apparatus is never in a condition so poorly adapted to stand dielectric strains as when first installed.

(5) Insulation tests require special testing apparatus and expert and experienced direction which are very often not available, and without which great risk is run in attempting such tests.

(6) As an exception to the above, paragraph (5), it is evident that some simple types of apparatus, such as insulators, high-tension bus-bar insulation, high-tension series transformers, etc., may be readily tested without great danger.

(7) Fuller discussion of paragraph (1). Potential strains upon dielectrics cause effects of two kinds.

(*a*) A constant tendency to puncture the dielectric, which is due to the presence of the potential and depends on the physical dimensions and nature of the dielectric, and which probably remains constant as long as conditions are unchanged, *e. g.*, physical or chemical state. This strain is almost mechanical in its nature.

(*b*) A tendency to heat or produce chemical change in the dielectric, largely the former. This is also due to the presence of voltage and is very much more marked with alternating current than with direct current. Though comparatively small in actual amount, this generation of heat is a dangerous thing, as it occurs within the body of the insulating material, which is usually a poor conductor of heat.

As insulation heats up, it becomes much less able to withstand the strain described in paragraph (*a*) above, and, further, the rate of generation of heat within the insulation itself becomes much greater. As a net result, if insulation under strain once reaches a sufficiently high temperature, it is practically certain to get still hotter and ultimately to break down. In other words, for continuous running it is necessary that the heat generated by the potential upon the dielectric be dissipated as fast as generated. In actual apparatus, the critical rise in temperature may be reached in as short a time as one-tenth of a second, perhaps, or, in other cases, only after a long time, perhaps an hour. The latter time would be required only in large bodies of insulating material, *e. g.*, in large capacity or high-tension apparatus.

Different kinds of insulating material combine the characteristics described under (*a*) and (*b*) in very different proportions. Gaseous dielectrics suffer substantially no heating, while solids and liquids practically have their breaking-down strength determined by this heat-factor.

In actual service, injuries to electrical apparatus usually result from overheating, dirt, moisture, chemical exposure, mechanical injury or wear due to vibration and occasionally a strain from lightning or over-potential stress. The latter strains, however, are rarely extremely severe, except as they may cause local concentration of potential in the windings of apparatus, as will be discussed later.

Thus the voltage time test, which is usually applied to finished electric apparatus, by no means reproduces all the conditions of actual service. On the other hand, it is of course true that apparatus which will stand a high disruptive test will usually stand better in service, so that such a test is of value.

If a high disruptive test is relied upon by a purchaser to determine the acceptance of apparatus and terminate responsibility on the part of the manufacturer, the latter will be tempted to design his insulation in such a manner as best to stand the disruptive test at the sacrifice of some features more valuable for preventing deterioration in actual service. This difficulty becomes a very serious one where unusually severe disruptive tests are specified in a contract.

(8) Fuller consideration of paragraph (2). With low-tension apparatus, little or no harm is to be expected from reasonable over-potential tests carefully made, provided insulation is in good condition. An exception should perhaps be made of dangers of local concentration of strain in high-tension generators or motors of small size, as will be explained later. The following discussion applies to high-tension apparatus chiefly.

The amount of heat generated within the body of a dielectric increases at least as fast as the square of the voltage. Fur-

ther, this loss, with constant voltage, may be increased several times by an increase of 100 degrees centigrade in temperature. This means that a strain of double potential continued for any length of time strains the solid insulating material far beyond any condition it will meet in service. Further, the ability to stand the strain will be determined rather by the facility for getting rid of the heat, which is usually of little consequence in commercial work, than by other features of the insulation more desirable for actual service; further, the hottest part of the insulation will be inside, so that the centre portion of the material may be badly charred, while the outer portion, the only part visible to the eye, has been kept cool and appears uninjured. This means that very serious injury to high-tension apparatus may be entirely beyond the possibility of detection until further developed by actual service.

Potential strains above a certain critical point cause a tendency for brush discharge over any insulating surface. If continued, this will deteriorate the insulation so that a discharge may continue afterward at a lower voltage. This effect will occur even under oil and, like the internal heat, will not be visible to the eye until in a very advanced stage.

When a coil is charged to a high potential and one end is suddenly discharged, there is a strain equal as a maximum to the full value of the discharge voltage, tending to cause the charge upon the turns of the coil to jump to the terminal through the insulation between the turns rather than pass around these turns. Since the total discharge voltage may be the abnormal voltage at which the apparatus is being tested and since this abnormal strain may be concentrated on a portion of one coil, where many coils are used to withstand the normal voltage of the circuit, it is evident that certain turns of the coil (which lie next to the terminal which is being discharged) will receive excessive strain. The condition which is essential to produce this concentration is that the discharge of the terminal of the coil shall be extremely sudden. This can usually occur only when the terminal is discharged by a spark close to the terminal itself, electrically speaking, *e. g.,* any accidental or other discharge between the wires used in applying the test, or in the apparatus itself, will tend to puncture insulation between turns at certain points within the winding. Such injury will oftentimes not be discovered, as the apparatus being tested is not in a condition to show a short-circuit when it is not connected to a generator. This danger is very serious with extremely high voltages. Apparatus may be protected against this strain by the use of choke coils, or high resistances, or static interrupters in the leads of the apparatus to be protected, provided no discharge occurs nearer the apparatus than the protective device. In this connection it should be noted that if the spark-gap is used as an auxiliary to measure the potential of the test, that satisfactory means must be used to prevent a discharge on the spark-gap from causing injury to the apparatus being tested.

The emphasis placed upon this particular phenomenon is not for theoretical reasons only, but because, in a number of cases, serious injury has resulted to apparatus therefrom. Furthermore, such conditions have been reproduced for purposes of investigation.

(9) Fuller consideration of paragraph (3).

In testing finished apparatus, it is manifestly impracticable to subdivide the windings into more than a very limited number of parts, *e. g.,* in case of the transformer, into more than possibly four parts. When such a portion is subjected to disruptive test, a breakdown may evidently occur in a number of ways, *e. g.,* between portions insulated only by air distances; over a surface of insulating material, which may be marble on terminal block, fibrous material or possibly the surface of oil in an oil-insulated piece of apparatus. Furthermore, breakdowns may occur through solid material, which in some places will be well ventilated and in other places will not be well ventilated. Sometimes portions of this material which in the disruptive test receives full strain, may when running in commercial service be so located as practically to receive a very much less strain. Such a point, for instance, would be the neutral point of a three-phase, star-wound generator. It is thus clear that if the severity of a test (as it must necessarily be) is determined by the strength of the insulation of the weakest spot of these various types and qualities of insulation, the other parts will receive an insufficient test. It may occur that a portion of the insulation less likely to give trouble in subsequent service will be this weakest portion, and will determine the whole test, leaving the condition of the other more vital portions of the insulation insufficiently tested.

(10) Fuller discussion of paragraph (5).

In tests made by persons inexperienced in such matters, there is grave danger of injury to apparatus which would not result when tests are properly made. Such difficulty may arise by the use of testing apparatus having too high an inductive factor or field reaction, so that current to the apparatus may either raise the voltage beyond the usual ratio or so deform the electromotive force wave as to cause an excessive strain; or by making tests when insulation is not in good condition; or in preliminary trials, in allowing tests to be on too long, though perhaps at a slightly lower voltage than the voltage of final test; or by improperly determining the temperature of the transformer; or in a number of other ways unnecessary to enumerate. Difficulty from this source is by no means of rare occurrence, and it is very difficult to avoid in large high-tension apparatus.

(11) Precautions to be observed in testing.

The most important precautions to be observed in making disruptive tests are here summarized:

(*a*) Insulation of all apparatus to be tested should be definitely known to be thoroughly drv.

(*b*) All insulation surfaces and the apparatus in general should be clean and free from all kinds of foreign matter.

(*c*) The measurement of the insulation resistance will sometimes give an idea of the fitness of the insulation for test. This condition will usually be determined not by the absolute value of the insulation resistance, but by a curve of the variation of insulation resistance as the apparatus is being dried out. When it has been increasing for a period and finally becomes steady with steady temperature, the drying operation is probably fairly complete. However, where air or oil spaces are included in the bulk of the insulating parts, these spaces may determine the insulation resistance so that no indication is given of the condition of the actual solid material.

(*d*) Before applying disruptive tests, it should be definitely determined that the temperature of no part of the apparatus to be tested is above that at which the test is to be made, remembering that tests of apparatus when hot, especially when very hot, are extremely severe.

(*e*) Electrical apparatus of large capacity, which necessarily contains considerable masses of iron and copper, lags behind the atmosphere in temperature changes, consequently when the atmosphere is damp and warmer than the apparatus, there is a tendency for the latter to "sweat" or condense moisture upon its

surface. This moisture will at least partially be absorbed by the insulation material and render the apparatus unfit for test; consequently, it is important in unpacking to open the packing case only when the air is cooler than the apparatus. In case of oil-insulated apparatus, the insulation should be protected from moisture when once dried out until immersed ready for service.

(*f*) The determination of the high-tension voltage actually reached during test is sometimes a difficult matter. The things to be avoided chiefly are the distortion of wave form or the change in ratio or transforming apparatus, or excessive drop due to the use of apparatus for applying the testing voltage, which is of insufficient size to supply the charging energy required by the apparatus to be tested. This subject deserves a full consideration, but has been so fully discussed elsewhere that further space will not be given here.

(*g*) In applying the potential of test to apparatus, the voltage should not be raised on the testing set to full value and then applied to the apparatus, but after connection should be increased rapidly by small steps, or continuously from a voltage not over one-half the final. Also, the voltage should be raised so quickly that the time during which the last ten per cent or twenty per cent of the voltage is being applied will be short, as compared with the duration of the full-potential test.

(*h*) To prevent local concentration of potential which results from any spark or breakdown occurring near the apparatus to be tested when the latter contains coils; choke coils, static interrupters, or resistance in series with the terminal of the apparatus to be tested may be used. The result essential to the avoidance of this local strain is the prevention of the strain caused by the above-mentioned breakdown from being transmitted without being smoothed out to the windings under test.

Evidently a choke coil in the lead of the apparatus will allow a change of potential to pass through it only slowly, and if this coil be made to have several times the choking effect of the smallest portion of the winding to be protected (next the terminal) which is considered to be able to stand the voltage of the test momentarily, the necessary protection will be obtained. It would seem that a resistance in the place of the choke coil would serve the same purpose and, in a measure, undoubtedly will. However, since the resistance does not absorb voltage until after considerable current strength has been attained, is it not as well adapted to protect from sudden changes of potential as the choke coil? The static interrupter being merely a choke coil whose power is increased by the use of the condenser, will act in same manner as the choke coil described above. Usually, however, except where static interrupters are provided for other purposes, the choke coil will be found more convenient.

(12) No complete recommendations are here made for specifications for testing apparatus for dielectric strength, but a few suggestions will be offered on topics in which there is probably a considerable diversity of opinion.

(*a*) In high-tension apparatus, *e. g.*, 20,000 volts and above, only moderate, short-time, over-voltage tests should be specified in contracts.

(*b*) Such tests should be made once for all when the apparatus is known to be in good condition, preferably at the factory, by experts, to give assurance that the specification has been met. Such tests should not be made a second time.

(*c*) After installation, a considerably lesser test should be made upon the apparatus, which will detect any serious injury in transportation and installation. Any moderate deterioration due to absorption of moisture, etc., will right itself with service, provided no abnormal deterioration has occurred.

(*d*) It is preferable to make high-potential tests by increasing the voltage upon the apparatus it is designed to operate, one terminal at a time remaining grounded, rather than making a high breakdown test by voltage from an external source.

(*e*) On tests of very high-tension apparatus, such as generators and transformers, no breakdown gap should be used in connection with the determination of voltage. Any error in the voltage of test, provided precautions as to the proper size of testing apparatus are used, will be comparatively unimportant. In some cases the voltage of the testing device may be determined by means of a spark-gap before the apparatus to be tested is connected to the circuit.

It must be borne in mind that in the above discussion the objections to over-potential tests and the dangers to apparatus involved, only, have been considered; and that it is not recommended that disruptive tests be abolished. Such tests may be and regularly are made successfully and are very desirable to ensure good insulation in electric apparatus and to determine the fulfilment of specifications. The point it is desired to emphasize is that great care should be taken to avoid injury to apparatus and that excessively severe tests, especially long-time tests at high-potential, should be avoided.

METHODS OF BRINGING HIGH-TENSION CONDUCTORS INTO BUILDINGS.

BY C. E. SKINNER.

One of the points in the design of high-tension transmission lines which seems not to have received general attention is the method of supporting and insulating the conductors which connect the transmission circuit with the apparatus in the generating and substations. Each engineer follows the plan which seems to him best for his particular set of conditions. In some cases the line is brought through a hole in the wall; in others, through an elaborate system of tubes placed in the wall; in others, through a piece of insulating material of some kind set in the wall; in others, the line is entered through an elaborate tower built for the purpose on the top of the building; in still others, it is taken directly through the roof of the building.

It is manifestly impossible to prescribe any fixed method for all voltages and all locations, as the requirements of each plant are varied by the local conditions, but much would be gained if the general requirements were outlined in such a way that designers of buildings and designers of plants could follow some general and accepted scheme which is known to be satisfactory for any given set of conditions. It is the purpose of this paper to discuss the general requirements rather than to give specific designs, although specific methods must necessarily be referred to in this discussion.

The method to be followed will depend on the following conditions:

(1) The voltage of the transmission circuit.

(2) The climate in which the plant is operated.

(3) The size of the high-tension conductor.

(4) The kind and height of building used.

(5) The conditions of approach to the building and the location of the apparatus in the building to which the high-tension line is connected.

The requirements which must be met are:

(*a*) The Maintenance of Proper Insulation of the Circuit—To maintain proper insulation, it is necessary either to allow sufficient open space about the wire to prevent any possibility of the current

striking across to the walls or surrounding material; or some insulating medium, such as a tube, must be applied to the wire to give the proper insulation.

(*b*) The Prevention of the Entrance of Rain, Snow, Cold Air and Dust—The entrance of moisture, snow and dust should be prevented both on account of damage to the contents of the building, and on account of the weakening of the insulation at the point of entrance. In most climates it is necessary that all openings be closed for at least a portion of the year.

(*c*) The Proper Mechanical Fastening of the Line Wire—The end-strain of the line must be taken up, and it is often convenient to combine the plans for taking up this strain with those for entering the building. This is particularly true where the transmission conductors are very large. It is also necessary to hold the wire in a fixed position where it passes through the opening into the building. This requires a more rigid line construction than is necessary away from the building.

(*d*) Reliability and Simplicity of Construction—It is self-evident that the construction must be such that it will be reliable under all circumstances. There are usually a sufficient number of troubles on high-tension transmission lines due to circumstances beyond the control of the engineer, without introducing any extra risk at the point where the wire enters the building. Usually, as in most other work, the simplest form of construction will be found the most reliable.

In general, wires are best brought through the walls of the building. The simplest form of construction consists merely of an opening in the wall sufficiently large to allow the proper air insulation between the wire and the wall, this opening being suitably protected from rain either by means of a large pipe set in the wall, sloping outward, or by a sufficient extension of the roof above, or both. The requirements of this form of construction are that the wire be a sufficient distance from the pipe, so that there will be no possibility of striking across under any conditions. The pipe should always be considered as "ground," regardless of the construction of the building. The cross-arms holding the wire inside and outside of the building should be sufficiently near and so braced that the wire will remain central in the pipe. This construction can be used to advantage only in dry, warm climates.

With potentials of 15,000 volts or lower a disc of glass or other fireproof insulating material placed over the wire at the inner end of the pipe will usually accomplish this purpose. In this case the tube must be sufficiently large so that the surface insulation over the insulating disc used will be ample to prevent trouble under the worst conditions which may occur. When there is any danger of condensation of moisture due to differences of temperature inside and outside of the building, two discs, a little distance apart, should be used. These discs may be cut so as to be placed in the pipe itself, or they may be cushioned and simply swung on the wire, lying against the ends of the

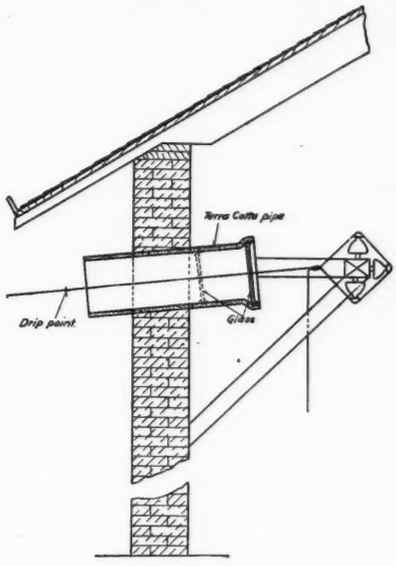


FIG. 1.

pipe. The surface insulation of the discs used should never be less than that of the line insulators, and as they will usually be less advantageously placed than the insulators, extra distance should be allowed, if possible.

With potentials above 15,000 volts, the form of construction becomes unsuitable

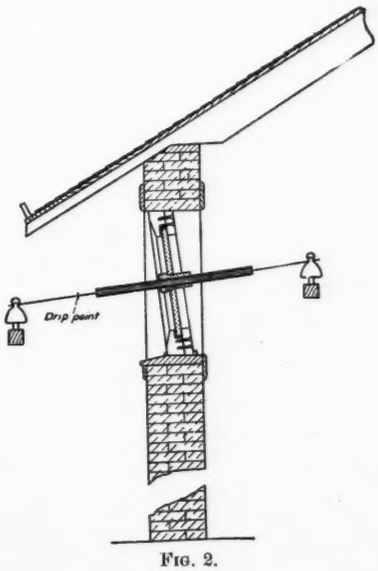


FIG. 2.

on account of the large size of opening required to give the necessary insulation distance over the discs. This may be true even with potentials below 15,000 volts under very adverse conditions. For the higher voltages, a long insulating tube of small diameter and very heavy wall may be placed over the wire and passed through a slab of insulation set in the wall of the building, the whole being protected from driving rain by an extension of the roof. The insulating tube should slope outward in all cases. Some form of drip point should be provided on the wire just outside the end of the tube. The insulation slab holding the tube should be large enough to prevent actual breakdown even though the tube is broken. Both tube and slab should be of fireproof material. This form of construction has been successfully used for potentials as high as 50,000 to 60,000 volts. The chief difficulty is in securing the proper insulating tubes. Glass and porcelain are electrically the best materials for the purpose, but when these are used it is usually necessary, on account of their lack of mechanical strength, to take up the end strain outside of the building by a suitably guyed pole.

The tower-construction may be necessary where the building is low, and the line wires must be carried at a considerable elevation in the immediate neighborhood of the building. It is generally very cumbersome and unsightly, and the bringing of the wires through the side of the tower presents the same problem as bringing them through the side of the building.

The bringing of the wires directly through the roof of the building, while possible, requires that extra precautions be taken to secure sufficient insulation and to keep out all moisture. This method, however well carried out, will probably constitute a danger point in the system.

In general, no combustible material should be used near the line wire, even when separated from it by insulating material sufficient to withstand the strain. Leakage or brush discharge is liable to cause burning sooner or later, and such burning is more serious at the building than the burning of a pin or cross-arm on the line.

The accompanying Figs. No. 1 and No. 2 are intended to show diagrammatically the two general plans recommended in this paper. Both plans, practically as shown, are in successful use by important transmission plants. It is expected that each engineer will find it necessary to make changes in details to suit his particular case, but it is believed that the plans proposed may be made effective for any transmission circuit.

The method of bringing high-tension wires into buildings should be carefully considered at the time the building is designed and proper provision made. It often happens that this point is given no consideration whatever, and the result is an unsightly and unsuitable arrangement made after the completion of the building and at an increased expense.

It is hoped that those having practical experience with the design and construction of this particular feature of the transmission line will take an active part in the discussion of this paper, and that by this means the Institute may be able to furnish general recommendations covering this subject.

SMOKE AND THE DETERMINATION OF ITS DENSITY.[1]

BY ALBERT A. CARY.

As to a scale of density to enable one to note the condition of the smoke, a number of expressions have been used to form a basis of comparison, but they unfortunately differ widely, and it is to be regretted that engineers have not yet been able to decide on some one definite standard upon which they can all agree which might be adopted for the expression of all smoke density measurements.

One method of expressing smoke's density is to call the densely black opaque smoke 100 per cent, and when the chimney is issuing an absolutely invisible vapor call it zero per cent of smoke, and then term the various shades between these two extremes as various percentages of smoke, according to its relative density. This system, although quite clever in its conception, depends too largely upon the varying judgment of different observers and so it is not very satisfactory.

Some have considered simply three degrees of smoke conditions; *viz.*, dense smoke, medium smoke and no smoke, but this scale is too limited to be of much value.

The English Smoke Abatement Committee of 1895 used four shades in its considerations, which proved fairly satisfactory. These were: dense, No. 3; medium, No. 2; faint, No. 1, and no smoke, No. 0; noting each condition by its corresponding numbers.

At the Paris smoke tests of 1897, five degrees were used, as follows: "very thick smoke," "black smoke," "medium smoke," "slight smoke" and " no smoke." This is the most satisfactory of all scales thus far described.

I have tried to use another scale which was suggested to me containing ten degrees of smoke conditions, but the divisions proved too numerous for easy quick application, and I have found that a scale of five or six degrees will express with sufficient clearness the condition of smoke appearance, and at the same time the differences between these degrees are not too fine definitions to admit of easy and quick determinations.

A number of devices have been used to assist the observer in determining density, these affording an opportunity to compare the smoke with some other shaded object. One of these consists of a number pieces of "smoked glass" of the same density in color, dropped one after the other into place across the section of a tube. The outer closed end of this tube is provided with a plane mirror set at forty-five degrees, so as to reflect light from above through the smoked glasses. This tube is placed to one eye, allowing the observer to look through the smoked glasses toward the mirror, while the other eye observes the smoke issuing from the chimney. As one after the other smoked glass is dropped into position a density is obtained similar to that of the smoke. The number of smoked glasses used are then noted to indicate the density of the smoke.

I have heard of a similar device which, instead of interposing successive pieces of smoked glass, uses a triangular prism having a metal top and bottom, the end or base of the triangle also being metal. The two sides of this triangular prism, meeting at the apex, are made of glass. The interior of the prism is filled with water (or alcohol) colored with a black coloring material, and the observer looks through the two glass sides, through the liquid across the prism along lines parallel to the base. As we look through a small depth of liquid, near the apex of the triangle, the interference to the passage of light being small, we see but a faint gray light, while when looking through the greatest thickness of liquid, near the base of the triangular prism, where the passage of light is greatly interfered with, we find an almost black appearance. The various positions between these two extremes giving us a large variety of intervening shades and by noting the width of the prism opposite our eye when a shade is obtained corresponding to the density of the smoke observed by the other eye, we can find an expression for the smoke's density.

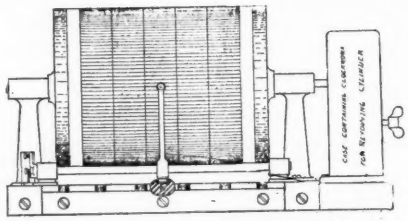


FIG. 3.—SEMI-AUTOMATIC DEVICE FOR RECORDING SMOKE DENSITY—FRONT ELEVATION.

There have been two smoke charts devised to assist observers in determining the density of smoke, one having been originated by Professor Ringelman, of Paris, while the second chart (which is an improvement on the one produced by Ringelman) was originated by the late Bryan Donkin, of England.

The Ringelman chart can be found reproduced in the transactions of the American Society of Mechanical Engineers in connection with "The Report of the Committee on the Revision of the Society Code of 1885, Relating to a Standard Method of Conducting Boiler Trials;" also in Kent's "Steam Boiler Economy" and in Bryan Donkin's work on "The Heat Efficiency of Steam Boilers."

This Ringelman chart is composed of six rectangles, the first being perfectly white, while the sixth is entirely black. The four intermediate rectangles contain a series of equidistant lines, drawn parallel to the sides of the rectangles. By hanging this chart between 50 and 100 feet away from the observer, we find that the cross lines blend together, forming a succession of tints, the shading from one tint to the next one being carefully modulated so as to form a definite succession of steps in gray colorings between black and white. By hanging this chart between yourself and the chimney, you can easily compare the different tints presented with the smoke issuing from the chimney and decide which shade in the chart corresponds to that of the smoke. In recording the smoke's density you can write down the corresponding number found on the chart, or in case you wish to make a finer distinction (supposing you decide that the shade of smoke falls between any two tints), take the smallest number and add a fraction to it, as for example, 3½, 4¼, etc. The number of cross line figures given in this chart are fully adequate for their purpose; any further addition would only lead to confusion, as has already been explained.

I know where this scale has been used on a percentage basis, calling the all white rectangle the zero per cent of smoke, the next twenty per cent, then forty per cent, and so on to the black rectangle, which, of course, corresponds to 100 per cent of smoke. The rule given by Professor Ringelman for constructing this scale is as follows:

No. 0, all white.
No. 1, black lines 1 mm. thick and white spaces of 9 mm.
No. 2, black lines 2.3 mm. thick, 7.7 mm. apart.
No. 3, black lines 3.7 mm. thick, 6.3 mm. apart.
No. 4, black lines 5.5 mm. thick, 4.5 mm. apart.
No. 5, all black.

With a scale constructed according to these directions, the observer will be obliged to place the chart over sixty feet away to obtain a blending of the lines into the desired tints and such a distance is often inconvenient. For that reason the charts produced in the works just referred to are plotted with their dimensions just one-half of those given above,

[1] Abstract of a paper read before the New England Cotton Manufacturers' Association.

which will allow their use at one-half the distance I have named.

Mr. William Kent received from Bryan Donkin (shortly before the latter's death) one of Donkin's smoke charts, which he has kindly placed at my disposal. This, like the Ringelman chart, consists of six rectangles, No. 1 being all white, while No. 6 is all black, the intervening numbers consisting of a series of flat tints of gray, ranging by definite steps in coloring from the white to the black.

This Donkin chart can be placed as near the observer as he may desire to place it, which feature entirely overcomes a serious obstacle which so frequently makes the Ringelman chart useless.

When making smoke density determinations it is desirable to note the condition of the smoke at frequent and equal intervals of time. Every half minute has been found a very satisfactory interval. When the test is an important one, not less than two separated observers should make records, with the time of observation carefully noted on their sheets along with the number expressing the shade of the smoke existing at that time; the separate records being finally compared and one checked against the other.

At the same time the above records are being made, some one in the boiler room should note the time of each firing and cleaning and also state the conditions existing at various other recorded times, such as "forcing the boiler," "running light," etc.

If furnace gas analyses are made during the time of these observations, and if the result of these analyses along with all of the other observed results is finally plotted on cross-section paper, we will be able to make a careful analysis of existing conditions pertaining to the production of smoke in the plant under consideration, and means for further suppressing the smoke can generally be found by making proper deductions from such plotted diagrams.

A time-keeping apparatus was used by the smoke observers during the Paris smoke tests (conducted in France between 1894 and 1897). This device contained a cylinder driven by clockwork, and around this cylinder is placed a paper on which the record is written (similar in manner to the paper placed on the drum of a steam engine indicator).

The drum of the smoke recording device is turned the same as the hands of a clock, a given distance around the circumference representing accurately one minute.

The pencil, pressing against this paper on the drum, is moved across the face of the cylinder (parallel to its axis) by the observer, who pulls the slide rod carrying the pencil to its extreme left position when there is "no smoke." This

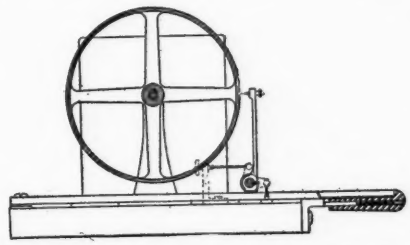


FIG. 4.—SEMI-AUTOMATIC DEVICE FOR RECORDING SMOKE DENSITY—SIDE VIEW.

causes the pencil to draw a line around the circumference as the clockwork revolves the cylinder, which line marks its zero position. When "slight smoke" was seen, the observer moved his slide rod one division to the right, which caused the pencil to mark a line around the circumference of the revolving cylinder a definite distance to the right of the zero line.

The slide rod was again moved another division to the right when "medium smoke" appeared, which caused the pencil to trace a new line, double the distance of the last one (for slight smoke) from the zero line.

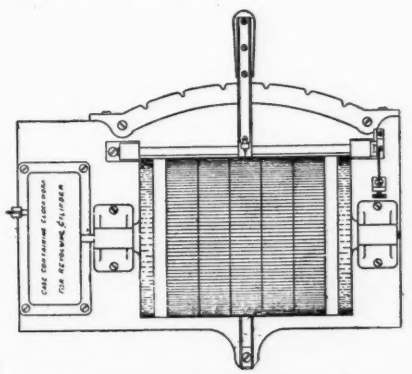


FIG. 5.—SEMI-AUTOMATIC DEVICE FOR RECORDING SMOKE DENSITY—PLAN VIEW.

As "black smoke" appeared, the pencil was again advanced to the right another equal distance, and finally, when "very thick smoke" appeared, the observer pushed the pencil as far to the right as possible, and so the five equidistant circumferential lines represent the five different degrees of smoke adopted by the Paris Smoke Test Commission, and with the recording cylinder constantly revolving we find our smoke record finally plotted on the paper the same as if we had hand-plotted it on cross-section paper, calling the ordinates time and the abscissa degrees of smoke density.

An apparatus of this kind was devised by the author, which is an improvement on the Paris machine. Fig. 3 represents the front elevation, Fig. 4 the end elevation and Fig. 5 the plan view of this apparatus. It will be seen that the pencil is moved along the length of the cylinder by means of a pivoted lever, the outer end of which is grasped by the operator's hand. As the lever is moved a spring detent slides easily into (or out of) one notch after the other in the segment on which the outer end of the handle rides, each notch holding the pencil in position on the paper corresponding to the degree of smoke observed.

Since producing this time-keeping apparatus the author has devised a further improvement on this machine, which allows the use of a long roll of ruled cross-section paper and also reduces the size of the smoke recorder.

The British Engineering Conference.

An engineering conference will be held in London from June 17 to 19, the third of the series of engineering conferences instituted by the Institution of Civil Engineers, with a view to enabling the engineers in all branches of the profession to meet together for the discussion of subjects in which they are mutually interested. The conference will be divided into seven sections—railways; harbors, docks and canals; machinery; mining and metallurgy; shipbuilding; waterworks, sewage and gasworks, and applications of electricity.

Among the subjects announced is a number of interest to electrical engineers. These include the following: "The Relative Advantages of Overhead, Deep Level and Shallow Subways for the Accommodation of Urban Railway Traffic," "Automatic Signaling," "Modern Equipment of Docks, with Special Reference to Hydraulic and Electric Appliances," "Internal Combustion Engines for Driving Electrical Generators," "The Comparative Merits of Direct-Current, Alternating-Current and Three-Phase Systems for Shipyard Systems," "Applications of Electricity to Driving Carriages in Town," "Transmission and Distribution of Single-Phase Alternating Current," "Wireless Telegraphy," "High-Speed Electric Traction on Railways." On the night preceding the opening of the conference, a lecture will be delivered by Mr. W. H. Moore, the subject being "Some Unsolved Problems in Engineering."

Railway Telegraph Superintendents.

The Association of Railway Telegraph Superintendents held its twenty-second annual convention in New Orleans, May 13, 14 and 15. The headquarters were at the St. Charles Hotel. The convention was called to order by President J. H. Jacoby, and the members were welcomed to the city by Assistant City Attorney McGuirk. The next annual meeting will be held at Indianapolis, Ind., on Wednesday, June 15, 1904. Mr. C. S. Rhoads, of Indianapolis, was elected president; Mr. C. P. Adams, of Chicago, vice-president, and Mr. P. W. Drew, of Milwaukee, secretary and treasurer. Following the election of officers, Mr. C. E. Yetman, of New York, explained the operation of a new typewriter transmitter invented by him, the instrument being exhibited by Mr. Yetman. This was followed by a talk by Secretary Drew on the history of the work of the association.

The American Telephone and Telegraph Company tendered an excursion to West End on the afternoon of the first day of the convention. Mr. Percival W. Miller, the company's special agent, was in charge, and at the conclusion of the luncheon remarks were made by several of the guests present.

A paper by Mr. William O. Maver, Jr., "Railway Safety Block Signals," was read by Mr. Jacoby at the opening of the second day's session. This was followed by a paper by Mr. Maver, on the subject of "Multiplex Telegraphy," which was read by the secretary. Several letters were read by Mr. C. F. Annett, of Chicago, detailing the great use of the long-distance telephone in railway wrecking service.

A paper describing a new switchboard was then read by Mr. W. W. Ryder, of Chicago.

Mr. G. L. Lang gave a description of the automatic telegraph circuit and signaling machine designed by Mr. C. K. Jones at the third day's session, and this was followed by the reading of a paper on "The Composite Telegraph and Telephone Circuit," by Mr. F. A. C. Ferguson. Discussion then took place, and a paper was read by Mr. F. F. Fowle on "The Transposition of Telephone Circuits." Mr. W. W. Ryder also read a paper on "The Telegraph Camp Train."

A Bust of Dr. John Hopkinson.

A bust of the late Dr. John Hopkinson was unveiled at the engineering laboratory of Cambridge University, England, on Monday, May 11. Addresses were made by Lord Kelvin, Dr. J. A. Ewing, Sir Joseph Lawrence and Principal Hopkinson.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

PROGRAMME OF CONVENTION, NIAGARA FALLS, JUNE 29 TO JULY 3, 1903.

Monday, June 29 (9.30 *to* 1)—*Institute and President's Day.*

President's address.

"Institute Branch Meetings—Their Organization, Development and Influence," by Calvin W. Rice.

"The Energy Transformations in the Synchronous Converter," by W. S. Franklin.

"Commercial Alternator Design," by W. L. Waters.

Lunch, 1 to 2.

AFTERNOON.

Visits to local points of interest. No prearranged programme.

EVENING.

"An Exhibition of the Hewitt Converter and the Mercury Vapor Lamp," by P. H. Thomas.

Tuesday, June 30 (9.30 *to* 1)—*Electrical Day—Railroad Papers.*

"High-Speed Electric Railway Problems," by A. H. Armstrong.

"Storage Battery Industrial Locomotives," by Frank L. Sessions.

"Predetermination in Railway Work," F. W. Carter.

"Car Run Tests," by W. E. Goldsborough and P. E. Fansler.

"Some Recommendations Concerning Electrical and Mechanical Specifications for Trolley Line Insulators," by Samuel Sheldon and J. D. Keiley.

"The Storage Battery in Substations," by W. E. Goldsborough and P. E. Fansler.

Lunch, 1 to 2.

AFTERNOON.

Technical tour of inspection of electrochemical and other electrical installations operated by Niagara Falls power, and the power-houses of the Niagara Falls Power Company.

Reception by Niagara Falls Power Company on terrace of power-house No. 2.

EVENING.

Dance under the auspices of local committee at Cataract House.

Wednesday, July 1 (9.30 *to* 1)—*Niagara Day—Power Transmission Papers.*

"On the Testing of Electrical Apparatus for Dielectric Strength," by P. H. Thomas.

"Choice of Frequency for Very Long Lines," by P. M. Lincoln.

"Method of Entering Buildings with High-Tension Wires," by C. E. Skinner.

"Y or △-Connection of Transformers," by F. O. Blackwell.

Lunch, 1 to 2.

AFTERNOON.

Trolley trips to Niagara Gorge, Fort Niagara, Brock's Monument, Chippewa.

Technical visits to following plants: Niagara Falls Hydraulic Power and Manufacturing Company, Canadian Niagara Power Company, Natural Food Company.

EVENING.

Entertainment, Cataract House, under auspices local committee and general committee.

Thursday, July 2 (9.30 *to* 1)—*Excursion Day—Miscellaneous Papers.*

"The Factors Which Affect the Energy Losses in Armature Cores," by J. Walter Esterline and Clarence E. Reid.

"Central Station Economies," by W. E. Goldsborough and P. E. Fansler.

"The Electrical Equipment of a Gold Dredge," by Ralph W. Montagu.

"The International Electrical Congress of 1904," by Elihu Thomson.

"The Legalized Standard of Electromotive Force," by H. S. Carhart.

"Symbols and Nomenclature," by Carl Hering.

"A Universal Telegraphic Code," by C. O. Squier.

"The Magnetic Units," by A. E. Kennelly.

Lunch, 1 to 2.

AFTERNOON.

Technical excursions to Olcott Beach, St. Catharine's, Lockport, Tonawanda substation.

EVENING.

Illumination of Gorge route.

Friday, July 3 (9.30 *to* 1)—*Buffalo Day.*

Joint meeting with the Society for the Promotion of Engineering Education.

Papers will be presented by the following members of the Institute: W. S. Franklin, J. G. White, E. H. Mullin, B. Gherardi, Jr., L. A. Osborne and T. J. Johnston.

Lunch, 1 to 2.

AFTERNOON.

Technical trips to Buffalo, Buffalo General Electric Company, Buffalo terminal house.

Adjournment of convention.

Canadian Electrical Association Convention.

The arrangements for the annual convention of the Canadian Electrical Association, to be held in Toronto, June 10, 11 and 12, are progressing satisfactorily. The new King Edward Hotel will be the headquarters of the convention, the business sessions being held there and also the annual banquet.

Among the social features there will be a tally-ho drive to the principal points of interest in the city, by courtesy of the Canadian General Electric Company; a visit by special cars to the works of the Canada Foundry Company, on the outskirts of the city, and a number of other forms of enjoyment not yet announced.

The committee on papers has secured a list of subjects covering a number of phases of electrical interest, the authors being recognized authorities on the subjects which they will take up.

The National Electric Light Association Convention.

A Large Gathering in Attendance at the Auditorium Hotel, Chicago, Ill.

[*Special Telegram to the* ELECTRICAL REVIEW.]

CHICAGO, MAY 26—The convention of the National Electric Light Association, which is being held in Chicago, Ill., May 26, 27 and 28, opened to-day under particularly agreeable auspices. There is every evidence that the attendance will excel any former meeting, and the rooms of the Auditorium Hotel are filled with exhibits of a very attractive nature. The association has a membership of about 540, and over three-fourths of the members have been registered, besides numerous visitors who are not members of the association.

The special train from New York came in over the New York Central and Michigan Central railroads at noon yesterday, arriving about two hours ahead of its schedule. The trip was made so agreeable, both as regards the prompt railroad service and the dining-car service, by the representatives of these roads, that strong resolutions of thanks were adopted and were sent to the railway managers. Mr. Cyrus O. Baker, who was in charge of the association train, was congratulated on the fact that a more successful special train was never enjoyed by the members.

On the arrival of the train a cordial welcome was extended to the passengers, about sixty in all, the reception committee meeting them at the depot and furnishing carriages to the hotels.

On Monday evening there was a grand reception at the Auditorium Hotel, which was greatly enjoyed and largely attended. The electrical visitors are being welcomed with old-time hospitality by Chicago, and the board of aldermen, at the request of Mayor Harrison and City Electrician Ellicott, tendered the freedom of the city to the visitors in a formal resolution.

Among the ex-presidents in attendance are Messrs. Huntley, Ayer, Insull and Doherty, all looking as if they were not a day older than when they presided over this important body. Other professional and central station men in attendance are Dr. W. E. Goldsborough, W. Worth Bean, Charles L. Edgar, E. H. Davis, Arthur Williams, John W. Lieb, Jr., N. F. Brady, E. F. Peck, Alexander Dow, E. H. Rollins, A. J. De Camp, George Redmond, C. D. Coe, B. J. Arnold, D. W. Low and R. D. Apperson.

The Tuesday morning session was called to order by President Ferguson at 10.15. The convention room was well filled, many new members being present. Mr. E. H. Davis, of Williamsport, Pa., acted as secretary, in the absence of Mr. James B. Cahoon, resigned. Letters of regret from numerous prominent men were read, including those from Mr. Thomas A. Edison, Professor Elihu Thomson and Mr. Charles F. Brush. President Ferguson read his annual address, which was well received, and a committee was appointed to consider its suggestions.

Mr. T. C. Martin presented the report of the Committee on Progress. This report was voluminous, and took up, in turn, the statistical growth of gas and electricity, incandescent gas lighting, made comparisons with conditions abroad, took up interesting data on storage battery equipment, high-tension overhead transmission, new types of arc lamps, high-tension underground transmission, motors and the electric drive, advances in electric heating, improvements in fuses, vacuum tube lighting, methods of charging for current, Osmium incandescent lamps, diffusion of light from arc lamps, street electrolier competition, central station chemical work, the Cooper Hewitt static converter, cheaper production of current, and state laboratories.

Following this, the report of the Committee on Office Methods and Accounting was presented. This paper elicited much discussion, in which Messrs. Doherty, Insull, Carson, Strickland, Bertrand, Newman, Scoville and Bean took part.

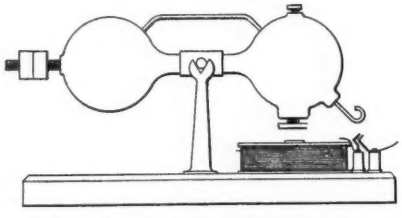
The first paper of the afternoon session was by Mr. Sidney Hosmer, on "The Advantages to Be Derived from Consolidation of Electric Interests." This paper was ably discussed by Mr. P. Junkersfeld and J. W. Lieb, Jr. The second paper was by Mr. A. Bement, of Chicago, on "Boiler and Furnace Efficiencies." The object of this paper was to discuss some of the features of the performance of modern standard apparatus. For this purpose two types of boilers and furnaces and one stoker have been selected. The paper described the type of boiler and the type of stoker, which was a chain-grate apparatus 65.5 square feet surface. The experimental work had three objects—first to determine the relative efficiency of the two boilers, and, second, the relation between the efficiency of the boilers and their furnaces, based on combustion and heat absorption, neglecting loss of combustible in the refuse. The two relative values to be determined were, for the furnaces, the loss due to escaping hydrocarbons and incomplete combustion, and for the boilers, the cooling effect produced. Efficiency curves were shown, based on the final temperature being constant through the full range of the initial. It appears that within usual working ranges, the final temperature remains quite constant. The value of the relative efficiencies from this standard of fuel saving is quite important. The entrance of air at the back end of the grate is, strictly speaking, a leakage. Its entrance is by way of openings at the side of the stoker, between the top and bottom chain and under the traveling grate, and into the furnace by way of the opening between the bridge wall and the end of the grate. For this leakage at the back of the fire there are two remedies. One is to make the opening for the discharge of the refuse only large enough to allow the ashes to pass out, and keep the end of the fire in contact with the bridge wall. The other method of stopping air leakage at the end of the fire consists in closing the openings at the sides of the stoker frame between the bottom chain and the floor under the stoker, and between the upper and lower chains. This paper was discussed at length by Messrs. W. L. Abbott, J. W. Lieb, Jr., Alexander Dow and King. The discussion of this paper was followed by a paper by Mr. John S. Peck, of Pittsburg, Pa., on "Standard Transformer Voltages," this paper being discussed by Messrs. H. S. Moody, P. D. Waggoner, C. C. Gartland, H. J. Gille, A. J. Wurts and W. G. Carlton. A paper by Mr. J. Henry Hallberg, on "The Application of Four-Ampere Series Alternating Enclosed Arc Lamps to City Lighting," was read. This paper was discussed by Messrs. W. d'A. Ryan, P. A. Bertrand, A. J. Wurts, Arthur Williams, J. W. Lieb, Jr., and W. Worth Bean.

A paper by Professor Elihu Thomson was read by W. d'A. Ryan, followed by discussion by Messrs. Ryan, Wurts and Lieb.

C. W. P.

Electrical Patents.

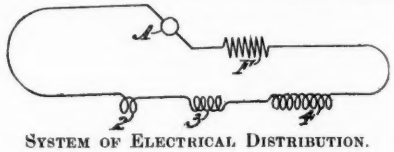
The General Electric Company has purchased a patent granted to Mr. Caryl D. Haskins, of Schenectady, N. Y., on a time-limit circuit-controller. This invention relates to circuit-controllers of that class in which a time interval is desired between the instant of an occurrence and the time at which an effect shall be produced on a controlled piece of apparatus. Such devices are employed, for example, in governing the operation of circuit-breakers. It is desirable that circuit-breakers should not operate instantly on a small percentage of overload, as motors and other electric translating devices are not damaged by the continuance of a moderate overload for a short length of time, and it is desirable not to have the service interrupted by a brief overload due to some momentary fluctuation, provided the circuit-breaker may be safely tripped within a time limit which would not endanger the safety of the generator or translating devices. Devices of this kind as commonly employed provide



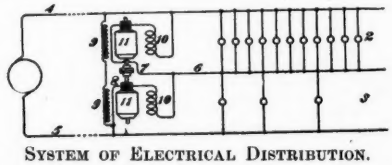
TIME-LIMIT CIRCUIT-CONTROLLER.

clockwork, the time-train being released by a magnet in the circuit in case of an overload and after a determinate interval serving to trip the circuit-breaker. If, however, the overload should cease within such interval, the clockwork is so adjusted as not to trip the circuit-breaker and to stop ready for another operation. With such apparatus, however, an uncertainty of operation results, as the operating parts are delicate and liable to get out of order from repeated use, from neglect of winding, and other causes. The invention contemplates the construction of a time-limit control device adjustable as to the time limit, not dependent upon clockwork, always ready for action, and of great simplicity of construction. A reservoir for a liquid is provided capable of being tilted or revolved on its bearings, so as to permit a flow of the liquid from one chamber of the reservoir to another, the duct through which the flow is effected being of such character as to require a definite and preferably adjustable time interval for a determinate quantity transfer. By means of the flow the circuit to be controlled is effected so as to trip the circuit-breaker or control the translating device of other character which is to be governed. Means are also employed by which upon a predetermined maximum overload the control circuit may be instantly affected so as to guarantee the safety of the controlled apparatus against such highly abnormal currents. The simplest form of the invention comprises a reservoir provided with an adjustable counterweight containing two chambers connected by a communicating channel and mounted on trunnions so as to be capable of tilting. One end is affected by an electromagnet in the governing circuit, which serves to tilt the reservoir when an overload occurs. In the reservoir a body of conducting liquid—such as mercury—is placed, although other mobile material—such as conducting pellets—might be employed. When the electromagnet is energized, the reservoir is tilted and the conducting liquid flows from one chamber to the other, and after a definite amount has been transferred contacts connected with the controlled circuit are completed, either directly by the conducting liquid or gravitatively by reason of the transfer of liquid. Moreover, by means of an adjustable device the level of the liquid may be altered so as to vary the time in which the contacts are connected.

The Westinghouse Electric and Manufacturing Company has purchased from Mr. Norman Rowe, of Wilkinsburg, Pa., a patent obtained by him on a system of electrical distribution. The object is to dispense with the plurality of generators heretofore employed at the central or power station in cases where balancing conductors have been used. Referring to the diagram, 1 is a direct-current generator located at the central or power station, and 2 and 3 are sets of translating devices connected in multiple series with the distributing mains 4 5. These translating devices are indicated diagrammatically as incandescent lamps; but they may obviously be of any character suitable for operation by means of the current and electromotive force supplied to the circuit by the generator 1. The two sets of translating devices 2 and 3 are connected at one side to a neutral or balancing conductor 6, as is usual in three-wire systems of distribution. Instead of extending this balancing conductor 6 to the central station and connecting the same between two generators, as has been the usual practice heretofore, the inventor proposes to locate at the load end of the circuit near such sets of translating devices two motors 7 and 8, the armatures of which are either rigidly connected together or are belted or otherwise geared together or to a single shaft, so as to run at either substantially the same speed or at different speeds, the ratio of which is substantially constant. Each of these motors is provided with a shunt field magnet winding and with a series field magnet winding 10. The balancing conductor 6 is connected at one end to the armature of one of the motors and to the outer terminal of the series field winding 10 to the other motor. The shunt windings 9 may be connected in series with each other around the armature and series windings of the two machines, as shown, or both of said shunt windings may be connected directly to the neutral conductor 6. The operation of the system is as follows: When there is no load upon the system or when the loads are equally balanced, the machines 7 8 will all run as differential motors and will provide mechanical power. If, however, the load is decreased upon one side or increased upon the other, the machine connected across the more lightly loaded side will continue to run as a differential motor, while the other machine will run as a generator, since the series coil of the latter is so connected as to cause the machine to overcompound, and the series coil of the machine running as a motor is so connected as to cause that machine to increase in speed under an increase in load. Thus by properly proportioning the series turns an approximately perfect balance of the voltage on the two sides may be obtained. It has been found in practice that the proportion of unbalancing which can be taken care of by this organization is equal to the combined rating of the two machines when used entirely to regulate their voltage or to their combined rating less the power delivered to some outside system when the machines are running partly as motors and partly for balancing purposes. It has been found by practical tests that this arrangement will maintain the voltages on both sides of the three-wire system substantially equal when the two motors are used partially



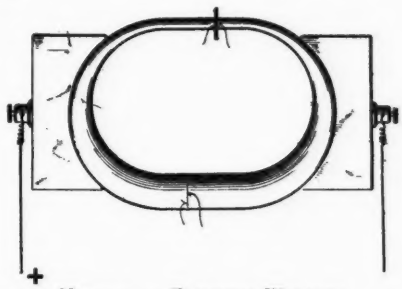
SYSTEM OF ELECTRICAL DISTRIBUTION.



SYSTEM OF ELECTRICAL DISTRIBUTION.

for driving other machinery and partially for balancing purposes, no adjustment being necessary between the condition of no load and that of fifty per cent overload. It will be readily seen that with this system the necessity of double units in series at the central station no longer exists, a single unit of twice the size being substituted therefor, and the middle wire from the power-house to the point of distribution being dispensed with. The higher efficiency of the larger units in the central station and the absence of losses incident to a long neutral or balancing wire will more than compensate for the losses incident to the employment of balancing-motors at the load end of the circuit. The cost of installation will also be less in general with this system than with the regular three-wire system, the smaller cost per horse-power of the larger units and the material saving in copper by reason of the omission of the middle wire except at the consumption end of the circuit being sufficient to more than offset the cost of the small motors necessary for balancing the circuit. This system is especially applicable to installations where the lighting or other unbalanced loads come at the time of day when the motor load is at a minimum. In such cases where the same machines are used for balancing and for power, little or no margin need be allowed on account of unbalanced loads.

Messrs. Joseph Shurek and Franklin B. Giesler, residents of Milwaukee, Wis., have recently obtained a patent on a method of electric welding, the invention having a special reference to the welding together of articles presenting different areas of surface at different welding points. For instance, in welding the two parts of a steel link, the side members of which are of unequal size, they proceed in the following manner: A pair of electrodes in the form of presser-blocks, which are shaped to conform to the shape of the articles to be welded, are arranged so that they may be simultaneously forced toward each other or separated. The two parts of the link are supported between these electrodes or presser-blocks, and a thin non-conducting plate of glass, gutta-percha, or the like is interposed between the welding points of least area. The current is then turned on and the presser-blocks forced toward each other. This pressure is maintained until the larger ends of the links, which are brought together, are welded. The pressure is then released momentarily, without cutting off the current, and the non-conducting plate withdrawn, whereupon the pressure is instantly restored to bring the smaller welding points into contact. The current will immediately weld these parts. Without the use of an interposed body of non-conducting material at the smaller points, it would be impossible to perform successfully the



METHOD OF ELECTRIC WELDING.

operation of electric welding with an article presenting extreme differences in the areas of surface at different welding points, for the reason that the electric current would burn or fuse away the metal at the smaller areas before the welding could be accomplished between the contacting surfaces of greater areas, but by carrying out the present invention this difficulty is entirely overcome.

Philadelphia Section, American Institute of Electrical Engineers.

The regular meeting of the Philadelphia branch of the American Institute of Electrical Engineers was held on Monday evening, May 11, at the Engineers' Club, of Philadelphia.

The chairman, Mr. Carl Hering, made an opening address. His remarks on Mr. Carnegie's offer for the Union Engineering Building were enthusiastically received by the members.

Mr. Philip Torchio, of the New York Edison Company, was present and presented a paper on "Safety Devices in Central Stations and Substations."

Mr. H. A. Foster gave an abstract of the paper Mr. H. A. Lardner had presented at the New York meeting on "Economical and Safe Limits in the Size of Central Stations."

Mr. J. T. Hutchings, of the Philadelphia Edison Company, gave an abstract of the paper Mr. Peter Junkersfeld presented at the New York meeting, on "Multiple *versus* Independent Operation of Units and Central Stations."

Mr. A. R. Cheyney, of the Philadelphia Electric Company, presented a concise abstract of the discussion held in New York on the three papers.

The general discussion was participated in by Messrs. W. C. L. Eglin, Horatio A. Foster, Carl Hering, Philip Torchio, Paul Spencer and J. T. Hutchings.

The meeting was well attended, and about fifteen members were present at the informal dinner at Boothby's restaurant, before the meeting.

Formal Opening of the Weston Instrument Company's New Works at Waverly Park, N. J.

The Weston Instrument Company tendered a reception to its employés and their friends on the evening of Thursday, May 21. This was to celebrate the formal opening of the new works of the Weston Instrument Company, at Waverly Park, N. J. An elaborate vaudeville entertainment was enjoyed, at the close of which Mr. Edward Weston made an address in which he detailed his plans for a harmonious cooperation of employé and employer. The remarkable market developed for Weston instruments was the result, he said, of agreeable interrelations between the working force and the executive management. He could foresee only an era of great prosperity for all concerned, if the happy conditions which now prevailed were continued.

A supper was served, at which seven hundred persons were entertained, and this was followed by dancing until a late hour.

The employés of the Weston establishment presented Mr. Weston with a loving cup, Dr. A. O. Benecke making the presentation speech. Among those present was Lieutenant F. B. Badt, western representative of the Weston company.

The Weston factories are built on the most modern lines. There are eight buildings in all, and these are finished in such a manner as to give the greatest convenience and comfort. In addition to excellent laboratory facilities for the development of new ideas, there is a large library, and a luncheon club has been established, for the convenience of which Mr. Weston has provided a refrigerating plant and kitchen, and a complete equipment of kitchen auxiliaries. This club is entirely under the management of the employés, a governing committee being chosen from among the workers, and the functions of which are directed entirely outside of the business management.

Electrical Interests Combined in New Orleans.

Several of the large electrical interests of New Orleans, La., have consolidated under the name of the Inter-State Electric Company. The companies entering this combination are the Safety Electric Manufacturing Company, the Newman-Sprangley Company, and Messrs. Sterns & Marks. The new corporation has a capitalization of $250,000. Mr. Charles Weinberger is president, and Mr. Lyman C. Reed is manager of the engineering department. The new company will carry a large line of electrical supplies and conduct a general electrical engineering and construction business. It is the ambition of the new officers to make this company the largest of its kind in the South.

Reviews of Current Engineering and Scientific Literature.

French Rules for Installing Electrical Conductors.

This article gives in full the recent decree for regulating the installation of electrical conductors in France. The first chapter gives specifications for installing aerial conductors, taking up the supports, insulators and special arrangements where the lines cross public roads, and conditions which must be maintained in the neighborhood of telephone and telegraph lines. The second chapter gives rules for installing underground conductors and special regulations which must be met when these conductors approach gas pipes or other electrical circuits. The third chapter gives special rules for railway installation, and the fourth chapter some general regulations covering the installation of transformers and the precautions necessary when approaching factories of explosives.—*Translated and abstracted from Revue Practique de l'Electricite (Paris), May 5.*

Investigations of the Sirius High-Efficiency Lamp.

The Sirius high-efficiency lamp is now being manufactured by a German firm. This is a type of incandescent lamp which gives a high economy, on account of the peculiarities of the filament. As yet, the lamps have not a long life, and the efficiency changes but little during use. The light given by this lamp is considerably whiter than that of the ordinary incandescent lamp, standing in this respect between the latter and the Nernst lamp. The cost of the Sirius lamp is about the same as that of the incandescent lamp. It is not particularly sensitive to changes in voltage. The author of this article gives the results of tests carried out upon ten 110-volt sixteen-candle-power lamps of this make. In order to obtain practical conditions, the supply was interrupted every eight hours, and the lamps were allowed to stand idle for one or more hours. Measurements were made every thirty hours, of current, potential and illumination. The results are given in tabular form, with three curves showing the average results. During 200 hours of burning, the average candle-power fell from fifteen candles to a little less than ten. The average watts per candle rose from 2.3 to 3.6. Current fell during the same time from 3.4 to 0.3 ampere. One of these lamps burned out within 100 hours, but the average life was about 160 hours. The short life obtainable at present deducts considerably from the efficiency, but it is thought that the lamp will be improved in this regard.—*Translated and abstracted from the Elektrotechnischer Anzeiger (Berlin), May 10.*

The London County Council Tramways.

This gives some particulars of the temporary power station built in the yard of the South London Electric Supply Corporation's works. A corrugated iron shed has been erected there, and in it are placed two 1,500-kilowatt Ferranti generators, direct-connected to Ferranti standard medium speed vertical engines. Steam is supplied from the boiler plant of the South London Electric Supply Corporation. The engines are governed by an automatic governor of the relay type, and an emergency governor has been fitted to act on the throttle valve. The valve gear runs at half the speed of the engine. These engines develop 2,500 horse-power each. The generators are twelve-pole machines, furnishing current at from 550 to 625 volts. Both sets will ultimately be used at the permanent station, which is now being erected. The standard Ferranti switchboard has been installed, containing generator, feeder and booster panels. This switchboard has one peculiarity, in that the negative busbar is not connected to the earth, current connection being made at the substation. The booster dynamos are small four-pole Dick-Kerr machines, taking 950 amperes and capable of raising the pressure forty volts.—*Abstracted from the Electrician, May 8.*

The Infra-Red Emission Spectrum of the Mercury Arc.

The high efficiency but objectionable color of the mercury vapor lamp have inspired numerous researches upon this lamp. In this article Messrs. W. W. Coblentz and W. C. Geer give the results of an investigation of the spectrum of this lamp, with particular reference to the infra-red rays. The lamp used was of the Arons type, and radiation from the tip of the arc was studied. The mercury was carefully purified, and the lamp exhausted so as to maintain a high vacuum. The current used was six amperes. It was found that the energy radiated consisted of a series of emission bands, but nowhere in the spectrum was the intensity of the radiation from the arc very great. This indicates a low temperature, like that of gases in vacuum tubes. Curves are given showing the distribution of the maxima, readings being taken by means of a radiometer. Correction was made for radiation from the glass, but correction for reflection was not made. Since glass is opaque for long wave-lengths, all the energy of the greater wave-lengths is absorbed by the glass in a lamp of the form described. This makes the apparent radiant efficiency of the arc greater than the true efficiency.—*Abstracted from the Physical Review (New York), May.*

Properties, Composition and Analyses of Gutta-Percha.

This gives an interesting discussion of those properties of gutta-percha, which make it valuable in electrical applications. At ordinary temperatures, gutta-percha is as durable as wood. It is flexible and as tenacious as leather; at temperatures from 100 to 500 it becomes plastic and capable of being moulded, and upon being cooled it returns to its original condition. The temperature at which it may be worked, depends upon the purity of the material. Good gutta-percha should not become plastic until it has reached seventy to seventy-five degrees, while the presence of certain adulterants causes it to become soft at thirty-five degrees. The purer the material, the more quickly does it regain its original position. Low temperatures do not affect it. Density of the material varies with its purity, pure gum having a density approximately equal to that of water. Its electrical properties vary with its purity. A thickness of one millimetre of good material can stand 16,000 volts. It is not soluble in water or alcohol, although the resines used in adulterating it are. This suggests a method of purification. It is, however, soluble in carbon bisulphide, chloroform and toluene. With heat, it may be dissolved by turpentine, certain oils and benzine. It resists the action of all acids except concentrated sulphuric and nitric. When exposed to the air, it deteriorates slowly, but lasts indefinitely under water. Methods are then given for analyzing the material and for determining the purity. The pure gum consists of three chemicals; one a hydrocarbon and the other two oxides of this hydrocarbon. It is suggested that the original gum consists of the hydrocarbon

alone. A good quality of gutta-percha contains sixty-five per cent of the pure article, not more than five per cent of mineral matter, nor five per cent of water.—*Translated and abstracted from L'Electricien (Paris), May 9.*

Slipping of Locomotives at High Speed.

The author of this article, Mr. C. E. Wolff, has made a study of the effect of the unbalanced vertical forces in locomotives upon the track adherence. He first sums up previous investigations, some of which have predicted that high speeds would be impossible, which predictions were not verified in practice. The author makes use of the results of Galton and Westinghouse's experiments on the coefficient friction at different velocities, and knowing the unbalanced weight on the locomotive drivers, he computes two sets of curves for two conditions. These curves show the track adherence for different positions of the driving-wheels and the corresponding tractive force. The conditions assumed were speeds of thirty-five and sixty-five miles per hour. In each case, the curve for tractive effort falls below that for track adherence at two points. This would seem to indicate that slipping would begin and consequently the tractive coefficient friction would decrease, so that continued slipping would take place; but since some time is required for the driving-wheel to increase appreciably in speed, this result does not take place. Calculations show that the total slip to be expected under the conditions assumed, is eighty-six inches per mile or three-eighths of an inch per revolution at thirty-five miles per hour; and eighteen inches per mile or less than one-tenth of an inch per revolution at sixty-five miles per hour. The smaller the diameter of the driving-wheels the greater would be the variation in adhesion, and it is thought that this fact may account partially for the better performance of locomotives with large driving-wheels.—*Abstracted from Mechanical Engineer (London), May 9.*

The Manufacture of Incandescent Lamps.

This article gives a detailed account of the process of manufacturing incandescent lamps at the works of the Sir Hiram Maxim Electrical and Engineering Company, London. A brief review of the development of the incandescent lamp precedes the description of the methods and material used at present. The method used in these works does not differ essentially from that employed in this country. The filament is made of cellulose prepared from Japanese paper or other materials. After dissolving this in some chemical, the material is placed in small glass holders with pierced bottoms, containing dies of sapphire. Compressed air is admitted to the top of the liquid, forcing the latter out through the holes into glass cylinders, which contain a proper setting fluid composed chiefly of alcohol. This solution is passed through hardening and purifying solutions, and then dried in air. The next step is to cut the filament to the proper lengths and wind it upon suitable carbon forms. It is then baked and is ready for mounting. A special machine has been devised to prepare the platinum leading-in wires. Two types are used, depending upon the size of the filament. That for attaching to the thicker filament is fed through an automatic machine which punches up a rivet head and then cuts the wire to the proper length. To attach the filament to these, the ends of the filament, held in a suitable clamp, are made to butt against the rivet heads of two platinum wires. The whole is then lowered into gasoline, or through volatilized hydrocarbon and the current passed through. The heat developed at the joint deposits carbon, cementing the wires to the filament and leaving a joint similar to a plumber's wipe joint. For smaller sizes of filament the machine flattens out the end of the platinum wire, giving it a spade shape. This is then drawn through a sapphire die, which bends it up into a small cylinder. The filament is cemented in the same manner. Methods of mounting the filament in the glass shank and the process of introducing the anchoring wires are fully described. The usual process of flashing is employed to make the filament uniform and of the proper existence. The lamps are exhausted first by mechanical pumps and finally by a mercury pump, and each lamp is photometered before it leaves the factory.—*Abstracted from Engineering (London), May 8.*

The Electric Tramway in Milan.

This is a short description of the tramway system of Milan, Italy. The lines radiate from a centre, forming as it were the spokes of a wheel, and are all connected by a belt line at an average distance of one mile from the centre, forming the rim of the wheel. The electrical station for operating the cars is located at Paterno and transmitted to Milan at 13,500 volts. The substation is at Porta Volta, where the energy is reduced to 3,500 volts. It is transmitted by underground cables to the substation near the centre of the town. This substation contains five motor-generator sets, having a capacity of 500 kilowatts, 315 revolutions per minute, converting the three-phase current into direct current at 550 volts. The station also contains two 250-kilowatt motor-generators and 260-kilowatt motor generators for lighting. The substation also contains a battery of accumulators, in which about 1,200 tons of lead are employed. These batteries are of the Tudor type and with a capacity of 20,000 amperes for one hour on the lighting circuit, or 3,800 amperes for one hour at 550 volts. The battery circuit has a Thury booster for charging. The motors of the motor-generator sets are synchronous machines and have given very satisfactory service. It has been found that with full load on the circuit, the machines will not fall out of step until the voltage falls from 3,500 to 1,700, and that at only half load it may fall to 1,380 without the machines falling out of synchronism. The motor-generators are started from the lighting circuit, the generator being run as a motor. The overhead trolley system is used, the wire being 9.28 millimetres in diameter. There are about 390 cars on the line, the city cars being fitted with only one motor. Experiments have been made with a special type of meter installed on the cars, and it is proposed to establish a premium for the motormen who run the cars most efficiently.—*Abstracted from Electrical Engineering (London), May 8.*

Secondary Radiation Induced by X-Rays.

As has already been noted in the ELECTRICAL REVIEW, Professor Arthur W. Goodspeed, of the Pennsylvania State University, has found that X-rays set up on secondary radiation from various articles, including the human body, which are sufficiently active to produce photographic effects. In an article in the *Pennsylvanian,* the official organ of the university, Professor Goodspeed explains his discovery.

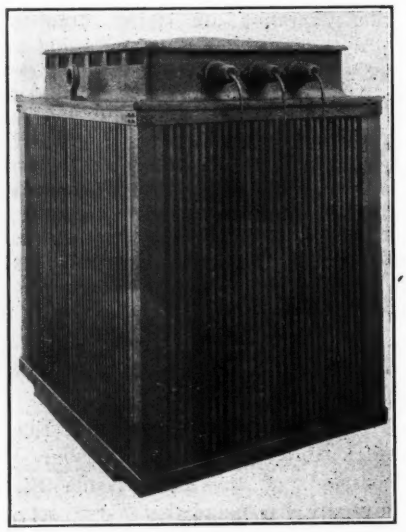
He has been convinced for some time that when an X-ray tube is in operation every particle of matter which is impinged by these rays becomes radiant. His work was to determine how great this effect was and for this experiment it is necessary to protect the photographic plate entirely from the direct action of the tube. He believes that he is the first who has positively demonstrated this action, although others have noticed it when the sensitive film was not perfectly shielded from the direct action of the tube. He also recalls a disagreeable inflammation from which he suffered and he now attributes this to the secondary radiation, as at the time of the work he was entirely protected from the direct action of the tube and was at a loss to account for his trouble.

INDUSTRIAL SECTION.

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS.

Self-Cooling Transformers.

In the Westinghouse transformers both high-tension and low-tension windings are divided into many flat coils. The high-tension conductor, in all transformers except the very small sizes, is a flat copper ribbon wound concentrically with only one turn per layer. The layers are separated from each other by a specially prepared insulting material in addition to the cotton covering of the conductor, while the coils are insulated individually and are separated by heavy insulating washers. This form of construction is such as to practically eliminate any danger of breakdowns between layers or from turn to turn—one of the most common troubles in transformer operation.



SELF-COOLING TRANSFORMER IN CASE.

The low-tension is wound in the same way with conductors of rectangular cross-section. In the larger transformers many wires are paralleled and are arranged in such a manner as to eliminate eddy currents in the conductors.

The advantages of this improved method of winding employed in the oil-insulated self-cooling transformer may be summed up by the maker as follows:

(1) The total electromotive force of the transformer is divided among many coils, reducing proportionately the strain within an individual coil.

(2) The electromotive force between layers is reduced to that of a single turn (ranging from ten to twenty-five volts).

(3) The coils may be spread apart at the ends so that a very large surface is exposed to the oil, thus providing ample radiating facilities.

(4) The regulation of the transformer is greatly improved by the interlacing of coils which is permitted by this method of construction.

(5) In case of damage to a coil another one may be substituted with little trouble and without returning the transformer to the works.

The importance of a free circulation of oil between the coils of a transformer is often underestimated. Its absence permits the interior to attain a temperature much higher than that of the exterior, resulting at times in the destruction of the coil insulating material by unequal expansion or contraction. The iron, as well as the copper, requires a low and uniform temperature to prevent deterioration.

Oil passages or ventilating ducts between the coils and in the iron provide an even heat distribution and a consequent uniformity of temperature throughout the transformer. The arrangement of these ducts between the coils is such that when the transformer is operated a vigorous circulation of oil is set up directly through the interior of this winding, and the ducts placed at frequent intervals between the laminations bring rapidly moving oil within less than one inch of every particle of iron in the transformer.

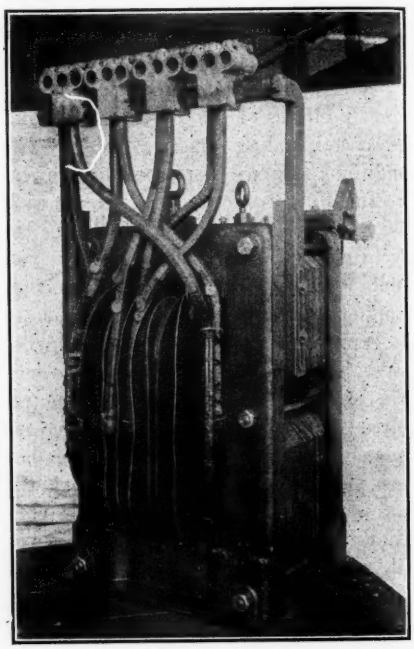
The amount of heat developed in a transformer depends upon its capacity and efficiency. In a 500-kilowatt transformer of 98.5 per cent efficiency there is a loss at full load of seven and one-half kilowatts or ten horse-power. Since this loss appears as heat, it must be disposed of, to prevent a dangerously high temperature.

This heat may be dissipated by simple radiation from the surface of the containing-case; by the circulation of water through pipes immersed in oil, or by the constant removal of heated oil and its return after having been cooled. The advantages of the first simple method are obvious.

To dispel the heat generated in a transformer of the self-cooling type a case with a large surface area exposed to the air is required. The greater the radiating surface, the lower the temperature. The Westinghouse transformers are mounted in heavy sheet-iron cases, protected by an outer framework of angle-iron. The surface area of the case is increased by corrugations, and is capable of radiating a large amount of heat.

The high-tension terminals are mounted on a marble slab at one end of the transformer, the leads being brought out through bushings. The low-tension terminals are mounted at the opposite end of the transformer on a steel bar heavily insulated with mica, making an entirely safe construction.

In a transformer the losses are of two kinds: (1) iron loss due to magnetic reversals in the iron; (2) copper loss resulting from the passage of current through the conductors. The iron loss, which is practically constant at all loads, must be very low if a high efficiency at small loads is to be obtained. These losses have been reduced to a minimum by careful proportioning of the iron and copper.



SELF-COOLING TRANSFORMER UNCOVERED.

In large transformers for long-distance transmission, close regulation is of even greater importance than in the ordinary small transformer for lighting circuits, as the drop in the line is often of considerable magnitude, and with raising and lowering transformers the transformer drop occurs twice between the generator and the load. This drop is greatly increased when the power-factor of the load falls below unity, as it does where current is supplied to induction motors. It is, therefore, particularly necessary that close regulation be obtained in transformers designed for transmission work, especially if used for supplying motors. This point has received careful attention in the design of the transformers described, and a very high standard of regulation has been attained.

Oil-insulated self-cooling transformers may be wound for practically any voltage

desired. The following high-tension voltages, however, have been adopted as standard: 2,200, 6,600, 11,000, 16,500, 22,000, 33,000 and 44,000. Taps are brought out from the high-tension winding for three lower voltages. This provision makes it possible to use duplicate transformers at both ends of the transmission line, the taps on the lowering transformers accommodating them to the reduced line voltage.

Transformers of a capacity not exceeding 150 kilowatts may be wound for voltages as low as fifty, and the larger transformers for voltages as low as one hundred. Either or both windings may be divided into two equal parts so arranged as to permit either series or multiple operation, the change being effected by a simple rearrangement of connectors on the terminal block. Taps may be brought out from the low-tension winding for ample variation in both voltage and ratio, and are provided for a total of five voltages; full voltage, five per cent and ten per cent less than full voltage, half voltage, and five per cent less than half voltage.

Oil-insulated self-cooling transformers may be arranged for transforming two-phase currents into three-phase currents and vice versa. Transformers are connected in pairs, and although the two transformers in each pair require slightly different voltages, they are of similar make, with a sufficient number of terminals for procuring the proper electromotive force for either position in the pair. In addition, provision may be made for one other three-phase voltage, five per cent or ten per cent lower than normal.

Transformers are often used to supply lighting systems, where, as the load and consequent line drop increase, it becomes necessary to raise the voltage of the system. Oil-insulated self-cooling transformers may be provided with taps which can be connected to a standard regulator dial mounted directly on the transformer case or switchboard. By means of these the secondary voltage may be varied by small steps from five per cent below to five per cent above normal voltage; this range can also be extended to ten per cent above and below the normal voltage.

In connection with either a two-phase or three-phase rotary, the oil-insulated self-cooling transformers which supply the rotary may be arranged for three-wire direct-current distribution. The Westinghouse Electric and Manufacturing Company manufactures a standard line of these transformers in sizes from 10 to 500 kilowatts, and for voltages up to 44,000.

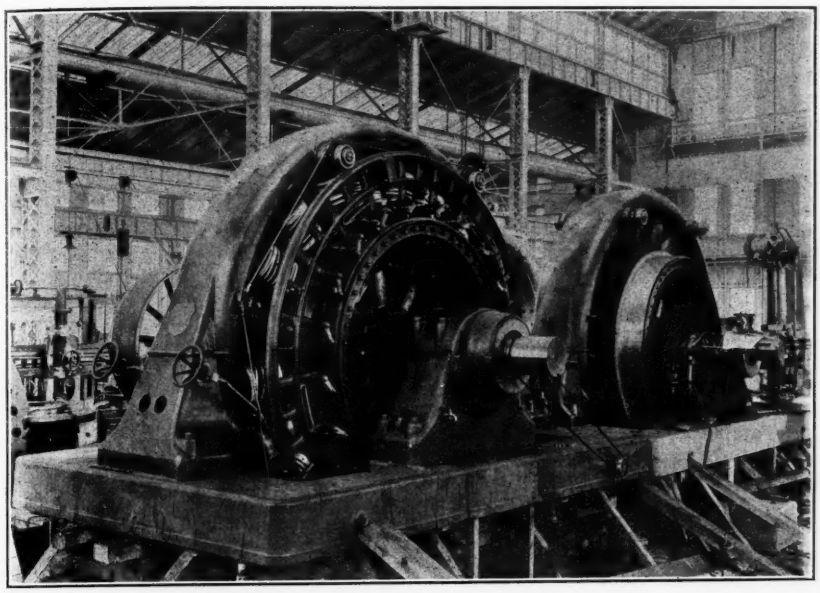


FIG. 1.—TWO 2,250-KILOWATT, DIRECT-CURRENT GENERATORS FOR PITTSBURG REDUCTION COMPANY, MASSENA, N. Y.

Two 2,250-Kilowatt Direct-Current, Double-Commutator Generators.

The accompanying illustrations show some of the recent products of the Bullock Electric Manufacturing Company, of Cincinnati, Ohio. The Bullock company has long held one of the first places in the design of direct and alternating-current machinery, it having been especially fortunate in the record-making operation of all classes of apparatus, from small motors to large-capacity engine-type and water-wheel-driven generators.

Fig. 1 shows two 2,250-kilowatt direct-current generators, with double commutators, built for the Pittsburg Reduction Company, and to be installed at Massena, N. Y. These machines operate at 140 revolutions per minute, and 500 volts, and are to be direct-driven by water-wheels. Four of these machines have been ordered from the Bullock company by the Pittsburg Reduction Company. In the tests of these machines they were speeded up 280 revolutions per minute, at which speed the commutators had 7,500 feet per minute peripheral speed. Notwithstanding this severe test, no faults were developed.

Fig. 2 shows a general view in the main aisle of shop No. 3 at the Bullock works. There are several large machines on the floor. Notwithstanding the apparent busy condition of this department, it is a fact that if the picture had been taken but a few days later, it would have shown the condition to be twice as congested as depicted by the illustration.

FIG. 2.—A GENERAL VIEW IN THE MAIN AISLE OF SHOP NO. 3 AT THE WORKS OF THE BULLOCK ELECTRIC MANUFACTURING COMPANY, CINCINNATI, OHIO.

A New Hand Vise.

The Utica Drop Forge and Tool Company, 296 Broadway, New York city, is putting another new telegraph or hand vice on the market. This company is noted for its rapid application of useful inventions, to facilitate the work of the lineman and the electrician. The tool illustrated in the accompanying engraving is claimed to be an improvement over the old style. As may readily be seen, this is fitted with a large loop and an improved butterfly-shaped thumb nut. The device is forged from special selected tool steel, and has finely finished and tempered jaws, the preparation of the tool being such that it may be relied upon for very severe service.

NEW HAND VISE.

Yost Key Sockets.

The accompanying illustrations show the interior construction of the Yost key socket, which the Yost Electric Manufacturing Company, of Toledo, Ohio, is placing on the market. Figs. 1, 2 and 3 show the cap, interior mechanism and shell. The cap and shell show the new locking device which secures the shell and cap together, without the aid of bands or screws. The bayonet slot in the cap and the headed pin in the shell indicate when the device is locked or unlocked, so that it can be operated without difficulty. The cap and shell can be separated and the socket interior removed in a very short time. It is convenient, as it is not necessary to carry screws and a screwdriver for the purpose of fastening, and there is less danger of inexperienced help injuring the socket. The device is strong and positive, and when locked can not be separated by a vertical pull or weight.

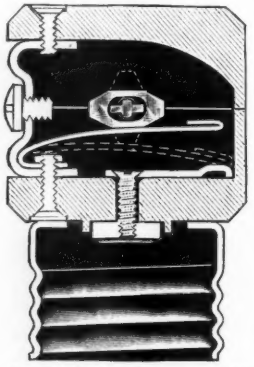


FIG. 4.—INTERIOR ARRANGEMENT OF SOCKET.

The cam and mechanism of the socket are so arranged and devised that a quick and positive break is made of over three-eighths of an inch. The current is carried by ample strong brass posts, covering fully all requirements. Fig. 4 gives an idea of the mechanical construction of the socket, showing all of the working parts, how the contact is made, and the distance between the contact points when the circuit is open.

FIGS. 1, 2 AND 3.—SHOWING PARTS OF SOCKET.

The company has just moved into a new factory four times larger than the one it has recently been occupying. The increased demand for this company's products has necessitated adding very largely to its factory facilities, and it is the intention very shortly to add further facilities to the plant. The buildings are all of one-story construction, giving a splendid advantage in lighting, and adding greatly to the convenience of handling the machinery which has been installed, and which is of the latest type. The company manufactures all of the parts going into its product, buying all its material in the raw state. The company intends adding a new line of electric specialties shortly, embodying several special features which it feels sure will meet with a popular demand.

New Type Fan Motors.

The accompanying illustrations show some of the new type fan motors which the Diehl Manufacturing Company, of Elizabethport, N. J., is placing on the market for the season of 1903. This company has a splendid reputation for its line of fan motors, and while the essential details of construction have not been changed to any considerable extent, there are numerous modifications which are claimed to be of great importance. The new Diehl desk fan shown in Fig. 1 has been improved in appearance by shaping up the body and reducing the weight, without affecting the original high efficiency. The new guard has four supports, and is secured to the body mechanically. A special feature in the design of this fan is that the two field cores are cast integrally, one frame making an unbroken magnetic circuit. These fan motors receive the same care in construction as larger motors and generators. The arma-

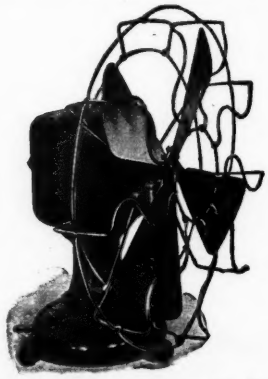


FIG. 1.—NEW TYPE DESK FAN MOTOR.

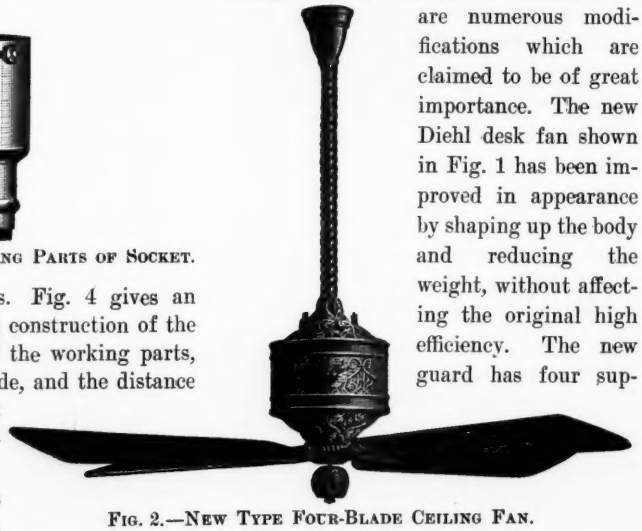


FIG. 2.—NEW TYPE FOUR-BLADE CEILING FAN.

ture is built up of thin, soft iron, with slots in the periphery, cut accurately for the reception and projection of the double silk insulated wire. The commutator is made of hard-drawn copper bars, with mica insulation. The self-aligning bronze bearings are also self-oiling, having an improved self-feeding wick oil cup. The brush-holders are unique in design, no wires being visible, and the carbon brushes are easily removed by unscrewing the fibre cap.

Fig. 2 shows a specially designed ceiling fan for high speed, giving two or three speeds if desired, furnished plain or fitted with lights. The four-light brackets give a spread of eighteen inches, eliminating the cluster effect. This type of fan has an ironclad armature and hard-drawn copper commutator mounted on a hollow steel shaft, case hardened, all of ample dimensions. The self-oiling bearings are so designed as to require replenishing once each season, and the construction is such that the oil can not be thrown out or drip from the bearings.

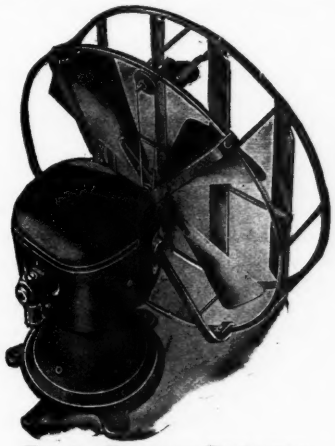


FIG. 3.—FAN WITH DEFLECTOR.

The brush-holders are of the same type as used on the desk fan. Fig. 2 shows a special form of this fan which is furnished with a casing on the pipe and four special Nyssa wood blades.

As an additional feature, the Diehl Manufacturing Company is prepared to furnish all of its desk and bracket fans with the Coleman combined deflector and guard. This is shown in Fig. 3. The Coleman deflector is simple in construction, and can easily be attached to any make of fan. It will distribute air through a maximum angle of 140 degrees, but, when desirable, the angle can be reduced by changing the pitman on the worm-wheel. The driving power is direct from the fan shaft by means of a small pulley placed between the fan blade and the bearing, a suitable belt from this pulley to a pulley on the worm driving the gear-wheel, every revolution of which changes the angle of the deflector vanes.

A New Telephone Receiver.

The Holtzer-Cabot Electric Company, of Boston, Mass., is placing upon the market its new telephone receiver, illustrations of which are shown in Figs. 1 and 2. The shell is made in two parts—the body of the shell and the cap.

Following the latest practice, binding-posts have been discarded. The terminals are entirely enclosed inside the shell, making a perfect electrical connection, and doing away with the danger of the user receiving a shock, while the cord, which is in all cases supplied with the receiver, is given a substantial hitch about the yoke of the magnet in such a way that no strain can come on the connections. Thus the life of the cord is greatly extended, while the work of renewing the cord is very slight.

FIG. 1.—NEW TELEPHONE RECEIVER.

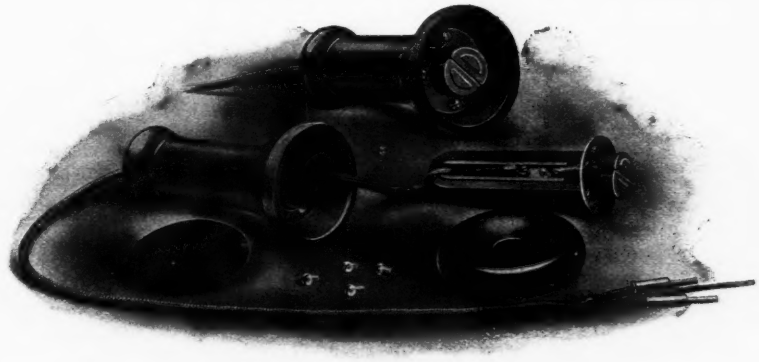


FIG. 2.—INTERNAL CONSTRUCTION, NEW TELEPHONE RECEIVER.

Fig. 2 shows the internal arrangement of the parts. The permanent magnets are of a special grade of magnet steel, while the pole-pieces are of the softest Norway iron. It will be observed that the construction is bipolar. The pole-pieces, being semi-circular in section, give an efficient distribution of the magnetic lines of force. This point is well brought out in Fig. 3. These diagrams are made by covering thin diaphragms with iron filings and holding them over the poles of the magnets. By gently tapping the diaphragm the iron filings are caused to arrange themselves in positions showing the direction and intensity of the magnetic lines in the region of the pole-pieces.

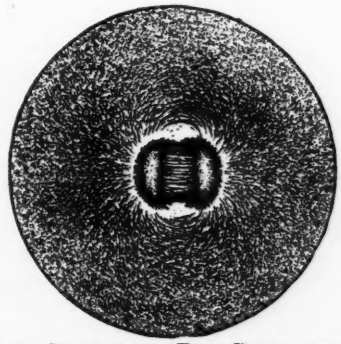


FIG. 3.—SHOWING THE EVEN DISTRIBUTION OF THE MAGNETIC LINES OF FORCE.

The adjustment feature has been omitted entirely and the receivers are permanently adjusted before leaving the factory. This is a distinct advance in receiver construction; only one adjustment is necessary and this should be made by the manufacturer.

The magnets are wound with silk-covered magnet wire, and corrosion is prevented by nickel-plating all exposed parts.

In connection with the unusually strong magnet a heavy diaphragm is used, making an extremely sensitive instrument and one that will respond perfectly through a wide range of conditions of transmission. These instruments are carefully standardized and are made with tools, jigs, etc., so that all parts are interchangeable. The receiver may be supplied with either pure hard rubber or composition shell and the cord may be furnished with either silk or worsted covering.

CURRENT ELECTRICAL NEWS

DOMESTIC AND EXPORT.

PHILADELPHIA LIGHT AND TRACTION DEAL—It is announced that the United Gas Improvement Company is engaged upon a deal involving the leasing of the American Light and Traction Company, of New York, a concern with $40,000,000 capital. The American Light and Traction Company, which was incorporated at Trenton, N. J., on April 6, 1901, is a corporation similar to the United Gas Improvement Company, its object being to acquire control of other gas, electric and street railway companies, and to operate gas, electric light and power plants and street railways.

CLEVELAND TROLLEY DEAL—The Cleveland Street Railway Company and the Cleveland Electric Railway Company will be amalgamated, and the operation of these two systems placed under one management. It is understood that the new company will have a capitalization of not less than $23,500,000. Senator Hanna, president of the Cleveland City Railway Company, and Mr. Horace E. Andrews, president of the Cleveland Electric Railway Company, will be, respectively, chairman and president of the Board of directors. The Cleveland Electric Railway Company has a capital of $13,000,000, and operates 136 miles of track. The Cleveland City Railway Company has an authorized capital of $9,000,000, with eighty-six miles of track.

INTERURBAN ELECTRIC RAILWAY SYSTEM—The Lackawanna & Wyoming Valley Railroad, which runs between Scranton and Wilkesbarre, Pa., was opened on May 20. The initial run is between Scranton and Pittston, a distance of eight and one-half miles. When the road is completed it will run from Carbondale, seventeen miles to the northwest, through Scranton to Wilkesbarre, nineteen miles to the southwest, passing through several mining towns of considerable size and importance. The road has been built and is equipped with all facilities for handling a heavy passenger and freight traffic. It runs over a private right of way the whole distance, and has terminals on its own property in each city. The terminal at Scranton covers nearly 100 acres of land, this having been the property of the Lackawanna Iron and Steel Company.

TROLLEY AND LIGHTING MERGER—The Metropolitan Street Railway Company, of Kansas City, Mo., and the Kansas City Railway and Light Company are to be taken over by the Kansas City Electric Light Company. The Equitable Trust Company is depository under the plan for the amalgamation of the street railway and electric light companies. By agreement, 100 shares of the Metropolitan Street Railway Company, of Kansas City, are exchangeable for 100 shares of the preferred stock and sixty shares of the common stock of the Kansas City Railway and Light Company, and 100 shares of the Kansas City Electric Light Company are exchangeable for eighty shares of the preferred stock and 100 shares of the common stock of the Kansas City Railway and Light Company. The Metropolitan Street Railway Company is capitalized at $23,000,000, and represents a consolidation of several Kansas City properties.

HYDROELECTRIC POWER PLANT IN COLORADO—Announcement has been made by General Manager G. A. Taff that excavations will be started at once for the power-house to be erected by the Hydroelectric Company on Ruxton Creek, Colorado Springs. It is the intention of the company to have the plant in operation by October 1 of this year. It is announced that everything is in readiness for the active laying of the water mains, in accordance with the terms under which the franchise has been granted. The first shipment of pipe is already on the way, and the route mapped out by the engineers will be graded, and the pipe line constructed. It will require about 15,000 feet of pipe to reach from Lake Moraine to the site of the power plant. The pipe will be twenty-one inches in diameter, and the aggregate cost of the pipe line alone is stated to be about $350,000. Later on it is the company's intention to build a second power station further up Ruxton Creek, in the vicinity of the Half-Way House; and when the entire system is installed, it will represent an investment of $1,000,000.

EXTENSIVE ELECTRIC RAILWAY SYSTEM FOR QUEBEC—It is announced that two main lines will be commenced this season for an extensive railway system through the south shore counties and eastern townships of Quebec. One system will connect Montreal with St. John's, by way of Longueuil and Chambly, and the other will run between Montreal and Valley Field, following the river bank, and taking in St. Lambert, La Prairie, Chateaguay and Beauharnois. It is stated that this will be one of the largest railway systems in Canada, and will form part of plans now being mapped out for an electric road to connect New York and Montreal. It is understood that connections will be made with important trolley roads in eastern New York, operating in the Berkshires, and several systems in Vermont. Among the lines that are expected to serve as feeders for the projected main line, besides the Montreal & Southern Counties Railroad, are the Troy Traction Company, the Bennington & Hoosick Railroad, the Hudson Valley Line, the Troy & New England Company, and the Berkshire Street Railway Company, with about fifteen other corporations of less importance.

PERSONAL MENTION.

PROFESSOR J. J. THOMSON has arrived in the United States, where he is to give a series of lectures on the latest developments in molecular physics.

DR. F. A. C. PERRINE, vice-president of the Stanley Electric Manufacturing Company, was a visitor to New York city last week. Dr. Perrine is making arrangements for a visit to California, on a tour of inspection of the long-distance high-tension transmission lines in that state, the apparatus and engineering features of which were designed and installed by the Stanley company.

MR. J. G. IHMSEN, general manager of the American Electric Telephone Company, of Chicago, Ill., has been appointed permanent chairman of the general committee upon arrangements for the reception of officers, members and guests attending the annual convention of the Independent Telephone Association of the United States, to be held on June 24 and 25 at the Auditorium Hotel, Chicago.

MR. WARREN B. REED, who went from New Orleans, La., to Nicaragua, Central America, about a year ago to establish an electric lighting plant, has been visiting the United States, arranging for machinery and equipment for four other light plants which he will build in Nicaragua. His first plant in that country is now in successful operation at Menagua, and is known as the Nicaragua Electric Company.

MR. BERNHARD ARTHUR BEHREND, chief engineer and chief designer of the Bullock Electric Manufacturing Company, Cincinnati, Ohio, was a visitor to New York last week, and read a paper before the American Institute of Electrical Engineers on "The Experimental Basis for the Theory of the Regulation of Alternators." While still a young man, Mr. Behrend has had a remarkably successful experience in the designing of alternating-current machinery. He has studied under Helmholtz, Slaby, Reidler and Kapp, and has been assistant chief electrician of the Oerlikon Company, of Zurich, Switzerland. Mr. Behrend has contributed liberally to the scientific and engineering press of the world, and was the originator of the proof and application of the circle diagram, now very generally used for the calculation and testing of induction motors. Mr. Behrend left the employ of the Oerlikon Company in 1899, and in 1900 was engaged by the Bullock Electric Manufacturing Company as chief engineer of its alternating-current department. In the short time which has elapsed he has produced a line of machines ranging in size from the half-horse-power induction motor to generators of large capacity.

TELEPHONE AND TELEGRAPH.

GALVESTON, TEX.—The Beaumont Telephone Company has increased its capital stock to $60,000.

NEW BRUNSWICK, N. J.—The council has granted a franchise to the New Jersey Telephone Company.

BUFFALO, N. Y.—The Interocean and Telegraph Company is building a line from Mann's Corners to Dansville.

CENTRALIA, ILL.—A franchise has been granted to the Farmers' Independent Telephone Company to do business in this city.

ALEXANDRIA, VA.—The Capon Bridge Telephone Company, of Capon Bridge, Va., has been incorporated with a capital of $10,000.

MADISON, WIS.—The Bloomer Telephone Company, of Bloomer, has filed an amendment increasing its capital stock from $8,000 to $15,000.

PORT HURON, MICH.—The Michigan Telephone Company will make between $10,000 and $12,000 worth of improvements to its lines in this city.

DALLAS CENTER, IOWA—The Farmers' Telephone Company has been incorporated by John Fox, Clyde E. Brenton and H. L. Repass. Capital, $25,000.

ITHACA, N. Y.—A certificate of incorporation of the Caroline Telephone Company has been filed in the office of the county clerk. The capital stock is $3,000.

INDIANAPOLIS, IND.—The Sulphur Springs Cooperative Telephone Company, of Henry County, has filed articles of incorporation with a capital of $7,000.

ONAWA, IOWA—The Onawa & Monana Telephone Company, with a capital of $100,000, has been incorporated. J. W. Huff is president, and Fred Warquis, secretary.

COUNCIL BLUFFS, IOWA—Articles of incorporation of the Potawattamie Mutual Telephone Company have been filed with the county recorder. The capital stock is placed at $150,000.

DOVER, DEL.—The Bourbon County Home Telephone Company, of Lexington, Ky., has filed a certificate showing that its capital, formerly $75,000, has been increased to $130,000.

DALLAS, TEX.—The Consolidated Telephone Company, of Wichita Junction, has been incorporated with a capital of $500,000, by E. E. Blake, Otto A. Shute, E. J. Simpson, all of El Reno.

WAYNE, N. Y.—A telephone company has been organized here by W. B. Jewell, Clifford Boyce, E. A. Washburn, Aaron Carlson, George H. Bliss, Frank Curren, Lewis Boyce and Joseph Hudson.

BANGOR, WIS.—At a meeting of the stockholders of the Bangor Telephone Company, held recently, it was decided to add the accrued earnings to the capital stock for the extension of the lines.

NORTH MANCHESTER, IND.—The Roann Telephone Company is arranging to enlarge its system, and has filed articles of incorporation with the Secretary of State, putting its capital stock at $15,000.

EMPORIA, KAN.—A new telephone company, known as the Dewey-Wareham Telephone Company, has been organized to operate in Central Kansas, and has been granted a charter by the Secretary of State. The capital stock is $50,000.

OTTAWA, QUEBEC—Reuben A. Zimmerman and F. Warnke, of Scranton, Pa., and F. J. Leonard, of Philadelphia, have applied for a charter for a company to be known as the Canadian Telephone and Telegraph Company, Limited.

STOCKTON, MO.—The Forest Grove-El Dorado Springs Telephone Company has completed its organization with the following officers: President, G. M. Liston; vice-president, C. C. Clawson; secretary, Charles Burrus; treasurer, W. H. Casey.

CHESTER, PA.—The Pennsylvania Railroad Company has ordered the construction of an entirely new telegraph trunk line between Philadelphia and Washington, D. C., to be built on the company's right of way, and has already four lines in service.

PORTLAND, ME.—The Lewiston & Auburn Telephone Company has been organized for the purpose of carrying on a telephone business with $250,000 capital stock. The officers are: President, Thomas R. Brooks, of Scranton, Pa.; treasurer, Edward W. Gearhart, of Scranton, Pa.

ALTOONA, PA.—A local telephone company has been organized and will build a line beginning at St. Clairsville and ending at Martinsburg, connecting Brumbaugh, Salemville, New Enterprise, Loysburg, Waterside, Woodbury and Curryville. Other lines will also be built later. The right of way has all been secured, and work will be pushed to completion as rapidly as possible.

ELECTRIC RAILWAYS.

MANSFIELD, OHIO—The Logansport-Wabash trolley line is now the property of the Union Traction Company, the latter company having purchased it for $850,000.

PHILADELPHIA, PA.—The Philadelphia Rapid Transit Company will build a double-track underground trolley line on Broad street. The total length will be thirteen miles.

MOLINE, ILL.—A twenty-year franchise has been granted by the board of supervisors to the East Moline Interurban Street Railway Company to build an extension from East Moline to Rock River. The line will be built this year.

SPRINGFIELD, OHIO—Articles of incorporation have been filed by the Springfield, Troy & Piqua Electric Railway Company, with a capital stock of $700,000. The incorporators are Governor Bushnell, John Bushnell, Dr. H. C. Dimond, W. G. Bowman and Fred J. Green.

CONCORD, N. H.—At a special meeting of the stockholders of the Concord & Montreal Railroad, it was voted to acquire, under an act of the last legislature, the property of the Concord Street Railway, and to issue for that purpose not exceeding 5,000 shares of capital stock.

STROUDSBURG, PA.—A company has been organized at Mount Pocono to build an electric railway from that point to La Anna, a distance of twelve miles. The officers are: J. B. Williams, president; John Houck, of La Anna, treasurer; E. D. Dunning, of South Sterling, secretary.

WASHINGTON, D. C.—A charter has been granted to the Luke, Westernport & Keyser Electric Railway Company, to build a line from Luke, Allegany County, through Keyser and McCoole, to a point opposite Keyser. The capital is $25,000, and the incorporators are: William Atkinson, Hugh Scott, Lonaconing; Marx Wineland, Robert Dean, Annan Frostburg and John Mackie, Westernport.

MARIETTA, OHIO—The Marietta, Woodsfield & Barnesville Railway Company has been incorporated under the laws of Delaware. It is capitalized at $200,000. The incorporators are: R. Merydith, F. M. Robinson and M. H. Hart, all of Marietta. The company will build an electric road to run through Washington, Monroe and Belmont counties, from Marietta *via* Woodsfield and Barnesville.

ATLANTA, GA.—A charter for the Atlanta & Marietta Electric Railway Company has been granted by the Secretary of State. The company is capitalized at $600,000, and the incorporators are B. D. Gray, J. D. Good, F. W. Montgomery, Warren Montgomery and Nathaniel Haven, of New York; P. D. McCarley, of Fulton County; A. H. and A. T. Cox, of DeKalb County; W. R. Bowen, R. W. Boone and J. L. Anderson, of Cobb County.

MOLINE, ILL.—Geneseo, Sterling, Rock Falls and Prophetstown men have organized the Rock River Traction Company, for the purpose of building an electric road from Rock Falls to Moline, by way of Prophetstown and Geneseo. The officers are as follows President, Levi Waterman, Geneseo; treasurer, William McNeill, Prophetstown; secretary, G. A. Stultz, Sterling. The company is capitalized at $200,000, but it is estimated that the road will cost $400,000. At Moline connection will be made with the interurban.

MUSKEGON, MICH.—The West Michigan Interurban Company has been formed. Its capital stock is $100,000, and its main office will be in this city. The proposed line which the company will build will run from Grand Rapids *via* Mill Creek, Sparta, Kent City, Casnovia, Canada Corners, Slocum and Wolf Lake to Muskegon, and from this city to Hart, passing through Whitehall, Montague and Shelby. The executive committee consists of F. A. Nims, J. K. Flood, W. E. Osmun, G. S. Johnson and E. M. Deane.

ELECTRIC LIGHTING.

COUNCIL BLUFFS, IOWA—An electric light plant is being installed at Guttenberg.

DES MOINES, IOWA—F. R. Payne will install a new electric light plant at Williams.

MONTREAL, QUEBEC—Windsor Mills has decided to invest in a municipal electric light plant.

OWOSSO, MICH.—The town has made a six years' contract for street lighting with the Owosso & Corunna Electric Company.

GREENSBURG, IND.—The city council has awarded a ten-years contract for street lighting to the Greensburg Gas and Electric Company.

QUINCY, ILL.—The Independent Electric Light and Power Company has been granted a franchise by the city council, and will soon begin the erection of a large plant.

SAN BERNARDINO, CAL.—The Edison Electric Company has let the contract for work on its Lytle Creek plant, the first contract amounting to $150,000, and work has been begun.

BRANCHVILLE, N. J.—The new power-house to be erected here will make use of Culver's Lake for generating power, and will light Branchville Borough and furnish light and power for Newton.

ALAMOGORDO, N. M.—Alamogordo men have secured the franchise for an electric light system at Tucumari. Those interested are J. H. Lawrie, M. H. Fisher, W. A. Hawkins and E. J. Dedman.

NEW DECATUR, ALA.—John J. Riordan, of Baltimore, Md.; William McComb, of New York, and others interested in the electric light and gas plants, are planning to expend not less than $50,000 in improvements.

PITTSBURG, PA.—The People's Ice and Storage Company and the Altmyer Electric Light, Heat and Power Company, of McKeesport, have merged under the name of the People's Ice, Light and Storage Company, with a capital of $500,000.

BELTON, TEX.—C. H. Denny, C. W. Meyers and Thomas Fairweather have purchased the Belton Light and Power Company's plant. The consideration was $21,000. A day circuit will be installed, giving the town the benefit of fans and motors.

SALEM, ORE.—J. J. Henry, of Denver, Col., has purchased the Salem street railway and electric light and power system from the Salem Light, Power and Traction Company. The price paid is not stated, but the property is valued at from $150,000 to $200,000.

COUSHATTA, LA.—The town council has granted a franchise for erecting an electric light and ice plant to W. H. Flemings. A company is now being organized for the purpose of constructing and operating the plant, and work is expected to begin in the early summer.

ST. JOSEPH, MO.—The St. Joseph Railway, Light, Heat and Power Company has secured a permit for the erection of its power-house, and it is expected that the plant will be in operation by October 1. Including the machinery, the cost of the power-house will be about $250,000.

SAN JOSE, CAL.—The Tuolumne Electric Company, which was incorporated recently with a capital of $250,000, will furnish electric power to the mines within a radius of twenty miles of Groveland. It is the intention of the company to commence the work of installing the plant in the near future.

TACOMA, WASH.—The Citizens' Light and Power Company has filed articles of incorporation with the Secretary of State, with a capital of $500,000. The object of the company is to furnish light, power, etc., to the city of Seattle. The incorporators are James J. McCafferty and James J. Kane.

AURORA, ILL.—The plans for the new power-house of the Fox River Light, Heat and Power Company have been completed, and it is announced that work will be commenced on the building within a short time, and that it will be completed during the latter part of the summer. The cost will be about $100,000.

WASHINGTON, D. C.—Perliminary plans for the construction of the Great Falls Power Company's plant have been completed, and contracts for the construction will be awarded shortly. The present plans provide for a generating capacity of 75,000 horsepower daily, with a minimum of 20,000 at low water.

IOWA CITY, IOWA—A franchise has been granted to the Guthrie Center Electric Light and Fire Company. The company is composed of local men, and will be ready for business in six months' time. The board of directors is composed of J. W. Foster, F. M. Hopkins, W. T. Anderson, O. D. Lemon, A. D. Gillespie, and others.

HYATTSVILLE, MD.—The Northern Electric Lighting Company, of New York, has been granted a franchise to establish a lighting plant in this city, and work will be started at once. The town has the right to buy the plant at the expiration of five years, at a price to be agreed upon by representatives of the company and town officials.

ST. ALBANS, VT.—All arrangements for the development of the water power of the Vermont Power and Manufacturing Company have been completed, and the details of the merging of the St. Albans Electric Light and Power Company into the first-named company are also complete. Power will probably be delivered in this city by the middle of the summer.

COLVILLE, WASH.—The Northwest Light and Power Company, which is putting in an extensive plant at Meyers Falls, is erecting poles and stringing its wires throughout the town, and it is expected that within a month Colville will be lighted by electricity. The plant is being equipped with a view to the distribution of both light and power to all the towns of Stevens County.

NEW LONDON, CT.—The General Assembly has passed the resolution amending the charter of the New London Gas and Electric Company. This authorizes the company to issue bonds to the amount of $750,000 for the purpose of retiring its present outstanding bonds, debentures and floating indebtedness. The company is also empowered to maintain and operate an electric street railway. The capital of the company is $425,000.

OAKLAND, ME.—The Oakland Electric Company, of Oakland, has reorganized, increasing its capital stock from $10,000 to $20,000, and has purchased from the Messalonskee Electric Company all of that concern's property in Oakland, including valuable water power privileges. The purchasers will at once proceed with the development of the power. The officers of the Oakland company are: President, Harvey D. Eaton; vice-president, John N. Webber; treasurer, William T. Haines.

WASHINGTON, D. C.—Proposals will be received until June 22 for the construction (including heating apparatus, electric wiring and conduits) of the United States post office at Stillwater, Minn. Similar proposals will be received until June 16 for the custom house and post office at Alexandria, Va.; also until June 18 for the post office at Boone, Iowa. Proposals are to be received until June 25 for the construction of the post office at Leadville, Col. This contract will not include the heating apparatus, electric wiring and conduits.

NEW INCORPORATIONS.

MONMOUTH, ILL.—The Illinois Electric Railway Company. $10,000.

WEST LIBERTY, IOWA—The South Prairie Mutual Telephone Company. $10,000.

SPRINGFIELD, ILL.—Marion Telephone Company. $15,000. Incorporators: J. B. Bundy, J. C. Mitchell, A. F. White.

COUNCIL BLUFFS, IOWA—The Western Iowa Independent Telephone, Telegraph and Terminal Company. $40,000.

SAN BERNARDINO, CAL.—Southwest Electrical Company. $25,000. Directors: C. M. Grow, J. W. Curtis, H. S. Roach, C. E. Gage and G. A. Roach.

DENVER, COL.—Maher, Crawford & Hotchkiss Telephone Company. $5,000. Incorporators: Ursen H. Graham, W. L. Savage, A. W. Morrow and Phil Woodring.

GAFFNEY, S. C.—The Electric Manufacturing and Power Company. $100,000. Directors: A. N. Wood, R. R. Haynes, S. B. Tanner, T. E. Moore, A. B. Groce, C. R. Willard, John B. Cleveland, J. F. Cleveland, and others.

ELECTRICAL SECURITIES.

Market conditions can be said to be much more favorable at the close of this week than they have been for some weeks past. The tendency to declines and sharp breaks prevailing for the past two or three weeks has made a great many traders fearful of entertaining any extended hopes for a positive upward movement. However, the past week showed a considerable improvement, and despite a slump on Thursday, the feeling is extant that better conditions will prevail.

A great deal has been said quite recently relative to the iron and steel industry, the drop in the price of pig iron having a good deal to do with the bringing of this industry before the popular view. The labor conditions in this department of industry have been more or less involved, but there is every evidence at the present moment that the summer's work will be advanced without serious difficulty.

ELECTRICAL SECURITIES FOR THE WEEK ENDING MAY 23.

New York:	*Closing*
Brooklyn Rapid Transit	62½
Consolidated Gas	202½
General Electric	183¾
Kings County Electric	200
Manhattan Elevated	137¾
Metropolitan Street Railway	129
New York & New Jersey Telephone	164
Westinghouse Manufacturing Company	195¼

The annual stockholders' meeting of the Interborough Rapid Transit Company will be held at 23 Nassau street, New York city, June 4. Books close May 27 and reopen June 5.

The governing committee of the New York Stock Exchange has listed $625,000 additional stock of the Kings County Electric Light and Power Company, making the total amount listed $3,125,000.

Boston:	*Closing.*
American Telephone and Telegraph	155½
Edison Electric Illuminating	270
Massachusetts Electric	86
New England Telephone	136
Western Telephone & Telegraph preferred.	95

A special meeting of the stockholders of the Edison Electric Illuminating Company has been called for June 2, to take action on the issue of 8,636 shares of new stock authorized by the Gas Commission on June 13, 1902.

Philadelphia:	*Closing.*
Electric Company of America	8 3/16
Electric Storage Battery common	74
Electric Storage Battery preferred	74
Philadelphia Electric	6 9/16
Union Traction	46
United Gas Improvement	90½

Philadelphia Electric directors have declared the regular dividend of 2½ per cent, payable June 15.

Chicago:	*Closing.*
Chicago Telephone	143
Chicago Edison Light	152
Metropolitan Elevated preferred	67½
National Carbon common	23½
National Carbon preferred	95
Union Traction common	3½
Union Traction preferred	32

The Chicago Telephone new stock, of which $2,000,000 has been authorized, will be issued at par to present holders in the proportion of one share to every six shares of present holdings. Half of the subscription price will be paid July 1, and the remainder October 1.

LEGAL NOTES.

POWER COMPANY HAS RIGHT OF EMINENT DOMAIN—Justice Britton, of Toronto, Quebec, has decided that the Ontario Power Company may take possession of land for its work, by right of eminent domain. This decision was made in the case which was brought by Mr. William Hewson, who owned land on the company's canal route, and declined to sell it on the ground that the company had not the right to take land as a railway does.

ELECTRICAL MANUFACTURING COMPANY FINED FOR CONTEMPT—The opinion of Judge Thompson, filed May 16, 1903, in the suit brought by the Westinghouse Electric and Manufacturing Company *vs.* the Bullock Electric Manufacturing Company, in the United States Circuit Court, Southern District of Ohio, Western Division, finds the defendant guilty of contempt in misconstruing the Tesla injunction. The original suit was brought to enjoin infringement of Letters Patent Nos. 381,968, 382,279 and 382,280. In his opinion the court holds that the defendant may have believed that it was acting outside of the scope of the order of injunction, but nevertheless violated the rights of the complainant.

WESTERN UNION WIRES REMOVED FROM PENNSYLVANIA RIGHT OF WAY—The United States Circuit Court of Appeals has held that the Pennsylvania Railroad has a legal right to remove the poles and wires of the Western Union Telegraph Company from along the railroad's right of way. This decision affirms a judgment of the Western Pennsylvania United States Circuit Court, and reverses a judgment of the Jersey United States Circuit Court. The opinion written by Judge Dallas states that the litigation is before the court on two appeals. One of them is upon a writ of error relating to an order of the Circuit Court of Western Pennsylvania, dismissing a petition by which the Western Union Telegraph Company sought to acquire by condemnation the use of the right of way of the Pennsylvania company and its branches for the use of the telegraph company's lines. The other is upon a decree of the Circuit Court of New Jersey, awarding an injunction restraining the railroad company and others from interfering with the telegraph lines along the right of way of the Pennsylvania Railroad Company. The opinion quotes the contract of the Western Union company with the Pennsylvania company, dated September 20, 1881, which contained a provision that after a period of twenty years, upon written notice given by the railroad company, the telegraph company would be bound to remove its lines whenever requested.

INDUSTRIAL ITEMS.

MR. F. N. MANROSS, Forestville, Ct., has doubled his factory facilities in order to keep up with the demand for his specialty. This is the manufacture of small springs and coil springs for instrument and fine work.

THE RUSHMORE DYNAMO WORKS has moved to larger quarters at 629 South avenue, Plainfield, N. J. This plant gives the company much greater facilities for the manufacture of searchlights and projectors for all manner of commercial use.

THE ELECTRIC APPLIANCE COMPANY, Chicago, Ill., will be pleased to send full descriptive literature on the subject of Gutmann wattmeters to any lighting plant in the United States. The company is especially desirous of covering the entire alternating-current field.

THE GENERAL INCANDESCENT ARC LIGHT COMPANY announces that its Chicago office has been removed to 1218 and 1219 Marquette Building. The "G. I." company is placing on the market a strong line of electrical specialties, and its western business has been growing to such an extent that more convenient and larger quarters were made necessary.

THE STOREY MOTOR AND ELECTRIC COMPANY, Harrison (Newark), N. J., has issued section "A" of its catalogue, descriptive of buffers and grinders. The Storey system of motor drive has been used with great success in many types of installation, and a number of testimonials is given in this catalogue as evidence of the satisfactory performance of these motors.

THE SHELBY ELECTRIC COMPANY, Shelby, Ohio, has contracted for a large brick building, to be finished by July 15. The building will be constructed as a wing to the present plant, and will double the company's capacity. The Shelby "flat coil useful light lamp" is meeting with a very popular demand, and the greater facilities are necessary to keep up with the increased business.

THE ELECTRIC GAS LIGHTING COMPANY, 195 Devonshire street, Boston, Mass., will be pleased to mail on application a fine catalogue descriptive of its hotel annunciator practice. This catalogue describes and illustrates a number of prominent installations of Ross return-call annunciators operated by telephone plug

boards, and telephone annunciators arranged for "Samson cable" system of wiring.

J. HOLT GATES & COMPANY, 1436 Monadnock Building, Chicago, Ill., has taken the agency of the Skinner Engine Company, of Erie, Pa. This company is also representing the Quincy Engine Company, of Quincy, Ill., for large Williams vertical cross-compound engines. The company is now in a position to erect complete steam and electric plants, either for alternating or direct current.

THE PENN MUTUAL LIFE INSURANCE COMPANY, of Philadelphia, has issued its fifty-fifth annual statement. On January 1, 1902, there were in force upon the books of this company 99,083 policies, for $242,051,662. The work of the year has added to this 29,729 policies, to the amount of $69,632,777. This company is a favorite among electrical men, and the general agent, Colonel Ezra De Forest, is widely known.

THE C. W. HUNT COMPANY, West New Brighton, N. Y., will be pleased to send to any one interested its illustrated pamphlet describing a complete line of coal-handling machinery. This company has had a remarkable experience in the manufacture of "industrial" railways, electric locomotives, coal-handling machinery, conveyors, steam-hoisting engines, electric hoisting engines, manilla rope and accessories.

JAMES S. BARRON & COMPANY, manufacturers of and wholesale dealers in electrical supplies, 200 to 206 West Broadway, New York city, are placing on the market the Barron universal telephone bracket. This is a substantial telephone holder, made entirely of highly polished steel, and finished either in nickel-plate or oxidized copper. The arm extends out fifteen inches when open, and closes up in a space of five and one-half by eight inches.

THE GRATON & KNIGHT MANUFACTURING COMPANY, Worcester, Mass., is in receipt of a large number of testimonials commendatory of the merits of its "Royal Worcester" belts. These testimonials are the result of honest work through a long period of time. The company will be pleased to quote prices and full information with regard to "Royal Worcester" belts, and requests a single trial in order to convince belt users of the accuracy of its claims.

THE B. F. STURTEVANT COMPANY, Jamaica Plain Station (Boston), Mass., has furnished a steel plate exhauster, direct-connected to a horizontal side-crank engine, for the ventilating equipment of the Lincoln Foundry Department of the United Engineering and Foundry Company, Pittsburg, Pa. The exhauster draws air from out of doors through a large steam heater built up in sections of one-inch pipe, one of the sections receiving the exhaust from the fan engine.

THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, Pittsburg, Pa., has recently sold to the Union City, Winchester & Muncie Traction Company two alternating-current generators, which will be used in connection with the extension the latter company is building to the Dayton & Northern division, now operating between Dayton and Greenville, Ohio. When the new extension is completed, through electric cars will be operated from Dayton, Ohio, to Muncie, Ind.

THE CUTLER-HAMMER MANUFACTURING COMPANY, Milwaukee, Wis., has issued a further series of price lists, Nos. 12, 62 and 64, which supersedes all earlier price lists of the same numbers. These changes should be noted and inserted in the copy of the perpetual catalogue, the old lists to be discarded. The "perpetual catalogue" idea of the Cutler-Hammer Manufacturing Company is designed to keep abreast with the constant modifications and developments which this company is making.

THE STANLEY ELECTRIC MANUFACTURING COMPANY, Pittsfield, Mass., announces, regarding future operations of the company, that it will continue to build and sell its well-known lines of apparatus, and will broaden the scope of the "S. K. C." system by adding complete lines of induction motors and arc lamps of the latest type. The company is developing a new series alternating-current arc lighting system, which is already in successful operation in several cities. Descriptive matter relative to this will be mailed on application.

THE LYON METALLIC MANUFACTURING COMPANY, sheet metal worker, has removed to its building at 18 and 20 South Ann street, Chicago, Ill. The company is supplying the market with a line of sheet metal goods, a number of its specialties being especially applicable in electrical workshops. The company makes an assortment of steel tote boxes and steel trays which are of great use in the assembly departments. An oily waste can, fitted with a self-closing hinged cover, is also a prominent specialty manufactured by the company.

THE GENERAL ELECTRIC COMPANY, Schenectady, N. Y., has received an order from the *Woman's Magazine*, St. Louis, Mo., to build an electric searchlight which shall exceed in size and illuminating power any heretofore constructed. This searchlight will be placed on the dome of the new building which the publishers of this magazine are erecting on University Heights, just out of the city limits, and in full view of the exposition grounds. This new searchlight promises to be one of the most striking advertisements yet employed by any publishing house.

THE LUNKENHEIMER COMPANY, Cincinnati, Ohio, manufacturer of brass and iron specialties, has recently placed with the Nernst Lamp Company, of Pittsburg, Pa., a large additional order for Nernst lamps of various sizes. The Lunkenheimer plant, which is new and modern in every way, is now illuminated throughout by this make of lamp. The Nernst Lamp Company is making rapid advances in its sales in New York, Pennsylvania, and in New England and Atlantic Coast states. Agencies have been established in every city of importance, while additions have been made in Salt Lake City, Utah; Denver, Col.; Lincoln, Neb.; San Francisco and Los Angeles, Cal.; Seattle, Wash., and generally through the Mississippi and western states.

THE CONSOLIDATED CAR HEATING COMPANY, Albany, N. Y., secured an order on May 19 from the Philadelphia Rapid Transit Company for electric heaters for 515 cars. The order is for the new type of cross-seat heater, which is twenty and three-quarter inches in length and three and one-quarter inches in diameter. The heater is to be operated at comparatively low temperatures, to avoid overheating of seats. All lead wires are brought out of the heater at one end, and carried in mouldings along the side of the car. This order was taken by Mr. Cornell S. Hawley, the company's general eastern agent, with offices in the Park Row Building, New York city. Mr. Hawley has closed contracts with the Interborough Rapid Transit and the Manhattan Elevated companies for more than 15,000 electric heaters.

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia, Pa., has closed a number of contracts recently for railway installations of chloride accumulator cells. Two contracts have been secured from the Portland Railroad Company for installations located at Yarmouth and Underwood Park, Me. The battery at Yarmouth consists of 216 cells, having a capacity of 134 kilowatt-hours. The other is located midway from the power-house on the same branch, and consists of 252 cells, with a capacity of 604 kilowatt-hours. Contracts have also been closed with the Seattle Electric Company, of Seattle, Wash., for a battery of 288 cells, having a capacity of 628 kilowatt-hours; the Waterville & Oakland Railway Company, Waterville, Me., for a battery of 220 cells, with a capacity of 205 kilowatt-hours; the Reading Power Company, at Reading, Pa., for a battery of 264 cells, with a capacity of 740 kilowatt-hours.

L. B. ALLEN COMPANY, INCORPORATED, 1335 Columbia avenue, Chicago, Ill., is the corporation formed at the time of the death of Mr. L. B. Allen, who was the earliest manufacturer of electrical compounds for electrical construction and commutator service. The products manufactured by this company consist of the Allen soldering stick, Allen soldering paste, Allen soldering salts, Allen commutator lubricant. Under the present able management of the company, the volume of the product marketed has so steadily increased within the past two years that it has been necessary to equip and operate a very much larger factory, and even the capacity of this increase is now taxed. A patron of this company recently remarked "All Allen products show that they do what is claimed for them and a good deal more, and, further, for twelve years the company has studied the technical or chemical side of its business and has steadily progressed in its work, so that it is not possible for new competition to seriously affect it."